PLANNING MODELS FOR EFFICIENT RESOURCE ALLOCATION ON PEASANT FARMS: SOME APPLICATIONS IN NORTHWESTERN DOMINICAN REPUBLIC

By

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To the Farmers of Entrada de Mao

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TABLE OF CONTENTS

Page

ACKNOWLEDGMENTS iv

LIST OF MAPS viii

LIST OF TABLES ix

LIST OF FIGURES xi

ABSTRACT xii

CHAPTER

I INTRODUCTION 1
- The Research Problem 5
- Purpose and Organization of the Study 8

II THE PEASANT AND HIS LAND: TOWARD A CONCEPTUAL FRAMEWORK 10
- Introduction 10
- The Peasant Farm-Firm 11
- The Peasant Household-Farm 14
- The Peasant as Subsistence Farmer 17
- Synthesis: A Conceptual Framework 24

III A NORMATIVE MODEL OF PEASANT FARMING . 27
- Introduction 27
- Linear Programming 28
- LP Models for Peasant Agriculture 30
- A Theoretic Normative Model 38
- The Normative Model: A Summary 40
- Testing the Model 42

IV THE STUDY AREA: FACTORS CONSTRAINING AGRICULTURAL PRODUCTIVITY 43
- Introduction 43
- Agricultural Constraints: Physical Factors. 45
- Agricultural Constraints: Cultural Factors . 50
- Conclusion 60

TABLE OF CONTENTS (Continued)

CHAPTER Page

V. THE STUDY AREA: FITTING THE MODEL TO THE FARM 62
Introduction 62
Areal Classification of Resources 62
Data Collection 63
Model Design 65
The Farm Models 81

VI ANALYSIS OF RESULTS. 87
Introduction 87
Description of Modal Farms 88
Normative Farm Plans 99
Optimum Diet Plans 126
Farm Revenues: A Summary 136
Optimum Man-Land Ratios 141

VII SUMMARY AND CONCLUSION 146
Summary 146
Conclusion 150

REFERENCES 156
Books and Articles 156
Unpublished Materials 160

APPENDIX

I FARM-LEVEL FIELD QUESTIONNAIRE 162

II TIMING OF SELECTED CONUCO CROPS. . . . 166

III YIELDS OF SELECTED CONUCO CROPS BY FARM 167

IV AVERAGE LABOR REQUIREMENTS FOR SELECTED CROPS 168

V SEASONAL RETAIL FOOD PRICES IN ENTRADA DE MAO. 169

BIOGRAPHICAL SKETCH 170

LIST OF MAPS

Map		Page
IV. 1	Entrada de Mao--Physiographic Features	44
IV. 2	Situation of Entrada de Mao--Communications	58
V. 1	Multi-Variate Areas of Uniform Agricultural Productivity with Location of Modal Farms in Entrada de Mao	67

LIST OF TABLES

TABLE		Page
V. 1	High-Risk Crop Groups Having a High (≥ 67%) Probability of Co-Failure, and Trimesters of Land Occupance	76
VI. 1	Crop Production, Destination and Revenue, Actual Conuco Situation, Farm I	90
VI. 2	Crop Production, Destination and Revenue, Actual Conuco Situation, Farm II	92
VI. 3	Crop Production, Destination and Revenue, Actual Conuco Situation, Farm III	94
VI. 4	Crop Production, Destination and Revenue, Actual Conuco Situation, Farm IV	97
VI. 5	Crop Production, Destination and Revenue, Actual Conuco Situation, Farm V	98
VI. 6	Activities Entering Plans at Fixed or Upper Limits	100
VI. 7	Optimum Conuco Crop Schedule, Production and Revenue: Basic Plans	101
VI. 8	Optimum Sisal Harvesting Schedule and Amounts: Basic Plans	105
VI. 9	Resource Shadow Prices for Labor and Land: Basic Plans	108
VI. 10	Optimum Conuco Crop Schedule, Production and Revenue: Risk-Spreading Plans	112
VI. 11	Optimum Sisal Harvesting Schedule and Amounts: Risk-Spreading Plans	115
VI. 12	Resource Shadow Prices for Labor and Land: Risk-Spreading Plans	116
VI. 13	Optimum Conuco Crop Schedule, Production and Revenue: Innovative Plans	119

LIST OF TABLES (Continued)

TABLE Page

VI.14 Effect of Risk-Spreading on Cash Crop Production: Innovative Plans 121

VI.15 Optimum Sisal Harvesting and Ropemaking Schedules: Innovative Plans. 123

VI.16 Resource Shadow Prices for Labor and Land: Innovative Plans 125

VI.17 Optimum Diets under Risk-Spreading Plans: Food Purchase Schedule and Amounts. 127

VI.18 Optimum Diets under Risk-Spreading Plans: Farm-Grown Food Schedule and Amounts . . 129

VI.19 Marginal Costs of Palatability Requirements: Risk-Spreading Plans 132

VI.20 Percentage of Recommended Dietary Allowances of Nutrients Supplied by Optimum Diets: Risk-Spreading Plans 134

VI.21 Percentage of Recommended Dietary Allowances Supplied by Current Estimated Farm Diets and the National Diet 135

VI.22 Marginal Costs of Nutrients: Risk-Spreading Plans. 137

VI.23 Summary of Revenues under Current Practices and Optimum Plans 138

VI.24 Current and Optimum Man-Land Ratios and Associated Net Revenues 145

LIST OF FIGURES

Figure Page

IV.1 Average Water Balance Graph for Mao 47

V.1 Distribution of Ratio of Size of Family Labor Force to Tareas of Conuco among Farms in Entrada de Mao 66

VI.1 Effects on Net Revenue of Increasing or Decreasing Number of Family Conuco Workers. 143

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PLANNING MODELS FOR EFFICIENT RESOURCE ALLOCATION ON PEASANT FARMS: SOME APPLICATIONS IN NORTHWESTERN DOMINICAN REPUBLIC

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One possible cause of low productivity in peasant agriculture is the inefficient use of farm resources. This study attempts to design normative land-use models at the individual farm level which specify plans which maximize the value of production within the limits set by resource quality and availability, culture, economic conditions, and technology. The twin geographic organizing concepts of man-land relations and spatial variation are employed in order to construct models which reflect the realities of the peasant farm within a local resource context.

It is argued that the peasant farm differs from its Capitalist and Socialist counterparts in that almost all labor is supplied by the household. Receiving no salary, but requiring food and other

necessities, this labor force represents a fixed cost to be borne regardless of the degree to which it is utilized. The peasant farm, therefore, may be properly regarded as an integrated unit, possessing both production and consumption functions. Using the technique of linear programming, the theoretical model which is developed simultaneously attempts to maximize the value of farm production by the most efficient application of land and labor resources, and to minimize the cost of consumption by the design of a least-cost, nutritionally adequate diet. The model selects the most rewarding combination of farm and household activities from an array of choices including cash-crop growing, food-crop growing, and food purchasing. Net revenue maximization is the result.

The theoretical model is applied to a peasant farm situation in Entrada de Mao, a community in the semi-arid northwestern Dominican Republic. Five modal farms, which represent the modal class of labor to crop-land ratios within the community, are modelled. The modal farms possess different physical resource bases, being located in various ecological zones ("multi-variate areas of uniform agricultural productivity" into which the region was divided in a previous study).

Net revenue-maximizing plans for each farm are generated under three different conditions: 1) risk is ignored as a consideration in peasant decisions, 2) the danger of drought loss is recognized, and risk-spreading as a locally practiced means of risk avoidance is

incorporated in the models, 3) innovative cash-earning activities of sunflower growing and ropemaking are included in the set of possible alternative farm activities. Results show that net revenues can be substantially increased and diets made nutritionally adequate on most farms by a more efficient allocation and application of production and nutrition resources. The practice of risk-spreading lowers a farm's productive potential, and has the effect of reducing the degree of specialization and commercialization. Sunflower growing is a feasible innovation within optimal farming systems, while ropemaking is not.

Notwithstanding the optimal use of resources, dual solutions to the linear programming models show that the monetary values imputed to farm land and labor resources are low and not comparable to national standards. As Entrada de Mao becomes connected to the outside world, it is to be expected that the disequilibrium resulting from the inequalities between imputed and nationally prevailing resource values will resolve itself by changes in the current agricultural system.

CHAPTER I

INTRODUCTION

In his presidential address to the Association of American Geographers, Edward Ackerman defined the overriding problem of geography as "an understanding of the vast, interacting system comprising all humanity and its natural environment on the surface of the earth" (Ackerman, 1963, p. 435). While a comprehension of the total man-environmental system is an idealistic goal, a hierarchy of subsystems can be identified and studied, using the techniques of systems analysis. One subsystem of critical importance today is the one whereby resources are converted into items of direct usefulness. As population pressure on resources mounts, problems connected with this subsystem take on a greater urgency.

Although the study of resource management is by no means the exclusive province of the geographer, he brings to the understanding of the resource-converting system two unique and valuable contributions. The first is his "organizing concept" of spatial variation (Ackerman, 1963). The geographer visualizes earth's resources as forming an intricate mosaic of distribution patterns. Furthermore, he sees the no less complex picture of spatial variations in human population densities, cultures, economies, and resource-converting technologies.

Therefore, the action of the subsystem on the face of the earth, subject to a multitude of spatially significant variables affecting both man and resources, takes on unique characteristics at every place. Recognizing the near infinite spatial manifestations existing in the subsystem, the geographer attempts to bring some order by analysis of the dynamics and principles of spatial differentiation, and classification of existing patterns.

The second geographic contribution to the study of the resource-converting subsystem is the unified concept of man and the land, the belief that the existence and functioning of either is unthinkable without the presence of the other. The ecological view of man in mutual interaction with the land is a constant and stabilizing theme of the discipline. Although the environmental determinism of the early part of the century and the excessive confidence in the power of human domination of more recent years mark deviations from the balanced image of man and environment in concert, there seems to be a return to the more moderate and traditional position.

The study of agriculture as one aspect of the resource-converting subsystem has always held special appeal to geographers because, perhaps, few activities exhibit so strongly and rationally the effects of spatial differences in physical and human resources, while farming is, as well, the quintessential man-land relationship. Agricultural investigations in geography have usually taken the form of land-use studies, as the natural focus of the themes of spatial variation and man-environmental interactions. Although most land-use studies analyze unique areal cases, some attempts have been made to relate cases to general theory through the use of land-use models. These models are either descriptive (portraying actual conditions) or normative (specifying what ought to be under given conditions) (Harvey, 1966). The normative model is of particular interest because it prescribes optimal forms of land use. It is therefore an invaluable planning tool and provides a potentially productive bridge between theoretical and applied geography.

In the present study, a normative land-use model was developed for a group of peasant farmers* in an area of the Dominican Republic. It was felt that an original geographic contribution could be made to the general problem of optimal land-use specification for peasant agriculture. In the small body of research devoted to this topic, several short-comings of interest to geographers may be noted. Firstly, other researchers have made little effort to integrate land-use plans at different scales of investigation. In other words, individual farm plans are not treated as pieces of a regional or national plan, and, similarly, regional plans are not translated into practical recommendations for action at the farm level.

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*Following the usage of Eric Wolf (1966), I distinguish between three classes of agriculturalists: the primitive cultivator, the peasant, and the farmer. The critical feature in this classification lies in the character of production and exchange relationships. The peasant operates in a context of social inequality where his surpluses "are transferred to a dominant group of rulers that uses the surpluses both to underwrite its own standard of living and to distribute the remainder to groups in society that do not farm but must be fed for their specific goods and services in turn" (Wolf, 1966, pp. 3-4). In this respect, the peasant differs from the primitive cultivator, with his quid pro quo exchange relationships, and the farmer, who is an entrepreneur actively exchanging for gain.

One reason for the failure to integrate individual production units into a larger regional unit results from the non-recognition of the spatial variation in resources. A preliminary regional inventory and areal classification of resources significant to agriculture at the farm level would provide a set of relatively homogenous subregions within which land-use plans might be interpolated to smaller or greater scale with ease. Although the regionalization of agricultural resources has been a traditional task of geographers, a search of the literature reveals no attempt to explore the agricultural potential of such resource regions through the application of normative models. In this investigation, such an approach was taken.

A second weakness in most optimizing land-use models devised for peasant agriculture is a more serious one, and dealt with at some length in later chapters. There seems to be exhibited in such models a fundamental misunderstanding of the peculiarly intimate relationship between peasant and land. In general, the Western and capitalist image of the farmer as entrepreneur has been carried over inappropriately to peasant farming models. While a substantial body of knowledge on the peasantry exists, few of the ideas therein have been applied in model designs. It was proposed in the present study that a more realistic concept of the peasant farm be developed and incorporated into a model devised for peasant agriculture.

The Research Problem

There are two grave problems confronting the majority of the world's peasants: low incomes and malnutrition. Although these are logically linked as symptoms of low productivity, solutions are often exclusively addressed to one or the other problem, rarely to both simultaneously. It is argued here that development plans for peasant agriculture which do not include provision for alleviation of both income and nutrition problems cannot promote effective advances in national welfare. Furthermore, development plans are frequently in conflict with the aspirations and abilities of peasant farmers. Specifically appropriate plans must be provided.

The failure of many past efforts does not obviate the pressing need for the development of peasant agriculture. Previous programs have often benefitted only that small percentage of farmers in a position to take advantage of new knowledge, techniques, institutions and incentives, while the greater number of peasants have remained outside of the mainstream of the national economy. Widening regional and class income inequalities have followed with inevitable political and social tensions. The facile assumptions of "pump-priming" effects and interregional and interclass diffusion of development have largely failed to materialize. Manifestations of the uneven growth in national agriculture are detectable in analysis of many of the problems facing the Third World: rural-urban migration, slum housing conditions, subsistance standards of living, rising food costs, and unemployment, to name only a few. Solutions to these problems are impossible without parallel solutions to the problems of the peasantry.

While economists have traditionally dominated the field of development, other social scientists have also been attracted to the peculiar problems posed by the development of peasant agriculture. Thus, it is not surprising that there are different approaches to the ways and means of improving the position of the peasant agriculturalist. It is generally agreed, however, that the central task at the farm level is to raise productivity. What would appear to be a relatively straightforward technical problem is complicated by the characteristics of peasant agriculture: small-size units of production, a limited resource base, a reluctance to abandon time-tested formulas which guarantee survival, if not wealth. Plans which accept these features as given have a greater chance of success than more ambitious ones, if only because they seek to change less.

Can productivity be significantly increased without major changes in institutions, technology and attitudes? At issue is the question of farm efficiency. If it can be shown that there are misallocations of resources on the peasant farm which inhibit productivity, these should be corrected before more radical and more expensive development schemes are undertaken.

It is contended in this study that such misallocations exist in many parts of the world. These may be long-standing, the result of cultural constraints to the full exploitation of physical resources. These inefficiencies are relatively intractable to change, reinforced as they are by centuries of practice, custom and belief. More amenable to correction are the resource misallocations brought about by a slowness to adjust to a rapidly changing milieu, a result of ignorance of conditions in the outside world.

Accepting the fact that the primary function and purpose of the peasant farm is biological subsistence, one may distinguish at least two sources of inefficiency brought about by lack of information. The first is knowledge of the comparative advantage or disadvantage that one or more cash crops may have vis-a-vis a food crop or its purchased counterpart. Shared by all mankind to some degree, the second source of inefficiency is incomplete knowledge of both human biological needs for nutrients and the nutrient content of foods. As a result, total food costs may be many times greater than necessary.

Promising avenues of research which deal with peasant farm inefficiencies are maximization of productivity through utilization of the principles of comparative advantage, and minimization of the cost of biological maintenance. While at first glance these problems seem distinct, they are in fact intimately and indivisibly linked for the simple reason that the utility of a food crop or food purchase is determined, in part, by the nutrient content of that food and the biological need for the nutrients it provides.* Consideration of comparative advantage, then, must include a food crop's utility, as well as its monetary value, when a choice is to be made among a cash crop, a food crop, or a food purchase.

The twin problems of productivity maximization and food cost minimization may therefore be restated as one: given the limited agricultural resources of any farm site, there must be found a set of farm activities which balance the need for food against the desire to maximize the value of production. This, in its most primitive form, is the problem the peasant farmer must face as he plans the forthcoming season's schedule of activities.

Purpose and Organization of the Study

The specific purpose of the study is the development and application of a framework and technique for decision-making at the farm level--an activity planning model--which allows the realization of agricultural potential for any physical resource area within the context of nutrient needs and cultural and technological limitations.

The written presentation in the subsequent chapters parallels the methodology used. In Chapter II, theories of peasant agriculture are examined in order to develop a conceptual framework of the peasant-land relationship so that a sound theoretical model may be designed. In Chapter III, a theoretical peasant farm production-maximizing model is presented following a discussion and review of the normative technique of linear programming and its application in areas of peasant agriculture and diet. In Chapters IV and V, the theoretical model is fitted to a real world situation, using data collected in a peasant community of the Dominican Republic. Spatial variation in agricultural potential is taken into account by application of the model to a selection of peasant farms in the community, representing different physical resource subregions. The farm models are further refined with the incorporation of local considerations of cultural preferences, economic and technological conditions, and agricultural risk stemming from climatic uncertainty. Activity plans specified in the normative farm models are presented and analyzed in Chapter VI. In the concluding chapter (Chapter VII), general agricultural recommendations for the community are made on the basis of the experimental results. The models are appraised and needs for future research are noted.

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*For a further discussion of the relation of this concept of the utility of food items to economic theory, see Prato (1972) or Smith (1963).

CHAPTER II

THE PEASANT AND HIS LAND: TOWARD A CONCEPTUAL FRAMEWORK

Introduction

Recently, an anthropologist carried out an intensive study in a Brazilian peasant community to investigate, among other things, the effects of the seemingly successful introduction of a cash crop (sisal) in an impoverished area of subsistence agriculture (Gross, 1970). He considered not only the increases in income level and the outward signs of wealth, but also measured the energy budgets of peasant households. His findings were disturbing: although real incomes had increased, nutritional status had worsened. This Brazilian example of "growth without change" illustrates the potential dangers of attacking the problems of peasant development without an adequate theoretical base.

Development of theories of peasant micro-economics in general, and of the peasant man-land relationship in particular, has not kept pace with the rapid growth of interest in peasant agriculture. While anthropologists and geographers have produced numerous empirical case studies, they have been reluctant to generalize their findings. Most economists, on the other hand, have tended to interpret peasant farmer behavior in the light of either Marxist or Western economic theory.

Among scientists who have given major attention to the study of peasants, several important theorists have emerged, whose ideas have fundamental implications for development policies. Some of the more noteworthy theories and ideas are discussed in the pages which follow for the purpose of isolating a set of postulates concerning the peasant's association with the land. These postulates will be used in the construction of a realistic model of peasant farming. With the belief that the peasant farm, like all beings and institutions, is a purposive organism, the approach used in this inquiry will be to analyze the nature and objectives of the peasant farm.

The Peasant Farm-Firm

Applying the theory of the firm, the neo-classical school of economists analyzes the peasant farm as if it were a business enterprise. The farm is split conceptually into two functional units: the farm as producer, and the household as consumer. It is on the former function that the neo-classicists focus most of their attention.

As a production unit, the farm-firm has at its disposal two important resources: land and labor. The goal of the farm manager is maximization of profits through the most efficient use of these factors of production. A question arises as to the possibility of reckoning profits on a family-worked farm, where no wages are paid. The neo-classicists reply that it is possible to impute values to labor expended on the basis of locally prevailing wages. Under profit maximization, it follows that each additional increment of labor used must further profit and that, consequently, there can be no redundancy of labor, nor disguised unemployment.

In criticism of the approach outlined above, Thorner (1968, p. 507) points out the serious inability of the farm-firm model to account for the continued survival decade after decade of peasant farms whose production "costs" (working expenses, rent, interest on capital, and imputed wages for labor) are greater than receipts (including estimates of the value of food crops retained for household use).

Theodore Schultz, with the publication of his classic Transforming Traditional Agriculture (1964), has emerged as one of the most articulate and influential proponents of the neo-classical view. While he has done much to dispel some of the more irresponsible and sterile doctrines surrounding peasant economics, the implications of his findings have perhaps allowed planners to dismiss the problems of the peasantry too easily, on the grounds that change without large capital investments is impossible. Schultz advances the hypothesis that "there are comparatively few significant inefficiencies in the allocation of the factors of production in traditional agriculture " (Schultz, 1964, p. 37). He reasons that the peasant farmer is agriculturally and economically rational, that peasant society is essentially static, and that, given enough time, the peasant will develop through trial and error a farm plan which yields near-maximum profits. Schultz spells out the main policy implications:

> . . . no appreciable increase in agricultural production is to be had by reallocating the factors at the disposal of farmers who are bound by traditional agriculture. It follows, therefore, that the combination of crops grown, the number of times and depth of cultivation, the time of planting, watering and harvesting, the combination of hand tools, ditches to carry water to the fields, draft animals and simple equipment--all are made with a fine regard for marginal costs and returns. (Schultz, 1964, p. 39)

Schultz concludes that the empirical data he cites confirm the hypothesis, although Lipton (1968, pp. 347-348) shows how these may be misinterpreted.

Schultz' doctrine, which would erase the hope of transforming peasant agriculture without significant external inputs, has been called one of "revolutionary pessimism " (Lipton, 1968, p. 329). What critics and policy-makers alike often seem to overlook, is the fact that the conditions for equilibrium stipulated by Schultz are rarely encountered in practice. Any community which has been affected by any recent "significant change" is excluded from Schultz' conclusions (Schultz, 1964, p. 37). Such change would presumably include such upsetting factors as population growth, inheritance,* and development in other sectors of the economy, as well as fluctuations generated by market forces (Beckford, 1966, p. 153) and random climatic events (Lipton, 1968). Indeed, one may infer on the basis of Schultz' argument that, where a static environment does not prevail, efficient farms may be the exception rather than the rule.

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*For an interesting exposition of the equilibrium-upsetting effects of land inheritance, see Stewart (1961). He argues that peasant inheritance systems have a built-in need for periodic land redistribution.

Mellor (1969, p. 217) makes the observation that it does not follow under Schultz' hypothesis that peasant farmers are especially acurate decision-makers, and "as agricultural development provides a dynamic environment, we may find a definite need for programs for helping farmers develop into better decision-makers."

The Peasant Household-Farm

In the first part of this century, a group of Russian scholars carried out detailed investigations of the Russian peasantry. The generalizations arrived at were unified as a body of theory with the publication in 1925 of A. V. Chayanov's Peasant Farm Organization. Chayanov and his colleagues were eventually condemned by the Soviet government as right-wing deviationists and their works suppressed. Chayanov's ideas have had little influence except in Japan, where an early Japanese translation of his essay was made. Not until 1966 has a translation been made generally available to the English-speaking world.

Chayanov refutes the neo-classical concept of the peasant farm as a capitalistic firm. Under the assumption that the peasant farm is exclusively family worked, Chayanov argues that profits cannot be maximized if they cannot be measured. Profits are based on the quantitative relationships between wages, interest on capital, and rent (Chayanov, 1966, p. 3). Because wages are non-existent on the family-worked farm, there can be no determination of profits. A capitalistic interpretation of peasant agriculture is therefore erroneous (Chayanov, 1966, pp. 3-5).

The peasant farm, Chayanov continues, must be treated as a single economic unit, composed of the household and the land. Production and consumption are indivisible and must be considered simultaneously. Wages, then, may not be imputed, because labor consumes as it produces. Rational economic analysis must be based on the relationship of the annual product of the farm to the cost of consumption as a single return to family labor (Chayanov, 1966, pp. 41-42).

What is the goal of the peasant farmer, then, if not profit maximization? It is the achievement of "a peculiar equilibrium between family demand satisfaction and the drudgery of labor itself " (Chayanov, 1966, p. 6). This equilibrium differs with land quality from farm to farm, and is affected by family size and the ratio of working to non-working members, as well as by personal inclination.

The farmer-manager manipulates the achievement of equilibrium "by introducing into the farm's organizational plan such labor investment as promises the highest possible labor payment per labor unit " (Chayanov, 1966, p. 7). Until equilibrium is arrived at, "the family, working without paid labor, has every cause to continue its economic activity"; however, "as soon as this equilibrium point is reached. . . , continuing to work becomes pointless, as any further labor expenditure becomes harder for the peasant. . . to endure than is forgoing its economic effects (Chayanov, 1966, p. 6). It is this willingness to work "uneconomically" (i. e., at zero or negative marginal productivity) which is the strength and durability of peasant farming in hard times (and perhaps its weakness in prosperous times?).

Millar (1970) has attempted to bring some of the more vulnerable aspects of Chayanov's theory into line with contemporary economic thought. Millar questions the relevancy of the question of profit maximization to Chayanov's argument. It is immaterial whether or not wages can be imputed in order to determine profits. The salient feature of peasant farms is that family labor is not a variable cost, but a fixed and overhead one (Millar, 1970, p. 222), and is determined by a notion of a minimum standard of living.

Millar argues that there can be no advantage to withholding family labor, as labor must be paid for whether it is worked or not. In the absence of outside labor opportunities, the family must work the farm in order to survive. In times of market adversity, the peasant cannot lay off workers, because of the integrity of the family unit. Instead, he is forced to increase the application of labor to gain the same standard of living as formerly (Millar, 1970, p. 225). This is in strong contrast to the behavior of the farm-firm under similar conditions.

The virtue of Chayanov's theory lies in the formulation and justification of the concept of the peasant household and land as an organic unit, producing, consuming, attempting at all costs to survive. Millar, by his characterization of family labor as an overhead cost, has permitted the use of conventional analytic tools in the theory's application.

The Peasant as Subsistence Farmer

Agricultural resources acted upon by a decision-making mechanism of human origin give rise to local manifestations of the man-land relationship. The decision-making mechanism varies spatially according to differences in agency and objective. In peasant communities the dominant agency is the unified household-farm, theorized by Chayanov.* The objective of peasant agriculture is subsistence--that is, farming for survival (Wolf, 1966, p. 15). The differing decision-making mechanisms of peasant and Western agriculture--that is, between the household-farm motivated by the need to survive, on the one hand, and the farm-firm guided by the motive of profit maximization, on the other hand, must be considered in analysis of present landscapes, and in specification of future optimal ones.

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*The functioning of the peasant household-farm was first analyzed in detail by Richards (1939), in her classic empirical study Land, Labour and Diet in Northern Rhodesia.

The peasant goal of subsistence--a term, as used in this study, which may best be summarized as the achievement of a culturally acceptable standard of living--by no means precludes market exchange or implies total self-sufficiency in foodstuffs. Confusion results when a distinction is attempted between "subsistence" and "commercial" agriculture. Subsistence agriculture is an objective, and a mixture of both self-sufficiency and exchange is usually necessary to fulfill physiological needs, societal obligations, and personal aspirations. Therefore, many farmers deliberately aim at both a degree of self-sufficiency and a market (Symons, 1967, p. 171).

A subsistence farmer's connection with the market does not necessarily involve a surplus food crop, as implied by Whittlesey (1936, p. 211) and others, but often a crop which he himself does not use--a cash crop whose sole destination is the market. Common food crops are often unsellable, especially in isolated communities, because all members are harvesting the same crop at the same time. In such a situation, the farmer wishing to enter the market would plant a crop whose value would be such as to justify transportation to a more distant market.* Hence, the frequent association in tropical peasant agriculture between food crops on the one hand, and sisal, coffee, oil palm or tobacco (to name only a few cash crops) on the other.

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*This generalization does not apply, obviously, to the Guatemalan Indian woman who walks to a market ten miles distant to sell twenty eggs. The market-place has many enticements apart from economic considerations.

Nash (1966, p. 82) observes that a cash crop is often an overlay on what is fundamentally self-sufficient agriculture, where "the organization, processing, marketing, and profit making [of the cash crop] lies largely in hands other than the producers." Kimmerly (1971) emphasizes the "dualism" between food and cash crops in Africa. Although both kinds of crops use the same land and soil, they differ in economic aims and social significance.

There is an undeniable attraction for the peasant farmer to enter the market to some degree. What is the advantage of producing a market crop to a farmer who is (or could be) nearly self-sufficient in food production? Hadder (1968, p. 105) is of the opinion that a supplemental cash income spreads the risks. Without the cushion of cash, a farmer is liable to starve in bad years, or go hungry regularly in the planting season (Hunter, 1967, p. 182). Attempts at total agricultural self-sufficiency would be perilous, if not impossible, where there was no recourse to either hunting and gathering, or purchase in lean times. The presence of a market can help to dampen the sharp fluctuations of supply in a pulsing environment.

Wolf (1966, p. 6) observes that the peasant is often forced to produce over his physiological needs because of social imperatives. These would include, especially, rent, taxes, and ceremonial obligations (Wolf, 1966, p. 15).

There are a number of items which the peasant needs in order to maintain a minimum standard of living. These are goods which he does not produce himself, and would possibly include fuel, medicine, services, clothing, and many foods which are deemed necessary. Purchased foods may be categorized as those which augment the farm-grown supply, those which supply the household in an off-season, those which are desired but not grown for economic reasons, and those which are desired but not grown for environmental reasons. Cash or barter is needed to obtain any of these articles. Peasant subsistence agriculture--agriculture designed to provide a minimum level of living--must of necessity provide a means for generating some cash income.

There is some controversy over peasant economic behavior beyond subsistence. Does the peasant cease production (or sale) when all living needs have been met, or does he continue in an effort to amass as much wealth as his resources will permit? Many observers conclude from the fact that the peasant commits only a portion of his resources to a profitable cash crop that he is aiming at subsistence, nothing more. This behavior may be explained, however, as risk aversion. Wolf, speaking of the peasant farmer, points out that an increased reliance on the market also increases risks and that "an all out effort to increase his ability to buy more goods and services. . . may spell his end as an independent agricultural producer " (Wolf, 1967, p. 517).

Another argument postulating the existence of so-called "subsistence mentality" is the fact that the peasant does not reinvest money to enlarge the scale of his operation. In reply to this, Mellor (1969) indicates that there is little to be gained from capital investment because of low returns. These in turn stem from backward technology and the fact that "many forms of capital goals can be formed directly from labor so that the returns [of capital] have been dispersed by the low level of returns to labor " (Mellor, 1967, p. 46).

Rogers, in his description of the "subculture of peasantry" points to the low aspirational levels found in a Colombian peasant community. He attributes these to fatalism, the image of the Limited Good, the reality of blocked opportunity, and the desire for inconspicuous consumption (Rogers, 1969, pp. 119-20). Castillo (1969, pp. 136-142) argues that low levels of aspiration may, in fact, be low levels of expectation.

Although several theories and studies strongly imply the existence of "subsistence mentality"--Chayanov's "peculiar equilibrium" comes to mind--little empirical evidence has been gathered to support this position (Lipton, 1968, p. 350, footnote 11). Schultz labels as "wrong doctrine" the idea that farmers are not responsive to normal economic incentives but instead often respond perversely, with the implication that the supply curve of farm products of backward sloping "* (Schultz, 1964, p. 8).

Weitz echoes what appears to be majority thinking on the subject: "the peasant in a developing country is not essentially different from any other mortal. He wishes to have a better life and to raise his standard of living " (Weitz, 1971, p. 10). To what extent he is willing to commit resources to this end is limited by a number of considerations, the most significant of which appears to be risk: "in other words, although the profit-maximizing principle obtains, it is limited by such factors as security and family welfare " (Beckford, 1966, p. 156). The peasant, although normally acquisitive, is not a simple profit maximizer. If he were, seasonal monoculture would be the dominant form of land exploitation in peasant economies.

The diversity of crops encountered on most peasant farms can be partially attributed to a combination of future uncertainty and poverty. Major sources of uncertainty may stem from unforeseen illness, non-ownership of land, unpredictable weather, fluctuation of prices and the value of money, and crop pests and diseases (Johnson,

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*Lipton, commenting on Schultz' statement, says: "the evidence against the backward-sloping supply curve was needed only by remaining True Believers in subsistence mentality (who, however, will not be swayed by mere evidence) " (Lipton, 1968, p. 329).

1971, p. 137). The relative importance of these factors will vary by farm and by region. By spreading resources over a variety of enterprises, the peasant farmer reduces the possibility of total failure, an eventuality which, given his limited assets, might spell complete ruin to him and future generations, entailing financial disaster, starvation, and loss of land and social status.

Farmer strategies for dealing with uncertainty are reflected in existing techniques, timing, and choice of enterprises--what may be referred to collectively as "survival algorithms " (Lipton, 1968, p. 340). Crops and crop combinations are selected which exhibit acceptable payoff-to-risk ratios. Risk-spreading, or hedging by crop mixing, is a common method by which farmers avoid the high risk inherent in total resource commitment to a single activity (Johnson, 1971, p. 71; Weitz, 1971, pp. 17-18). Crop-mixing is not solely a result of hedging strategies. It may serve a number of more positive ends, such as the avoidance of a highly fluctuating labor year, variety of diet, soil management, and the prevention of concentrated single stands to serve as a pest reservoir--although the validity of this latter purpose is open to some question (Janzen, 1973, p. 1214).

There seems to be no consensus among investigators as to the significance risk aversion plays in peasant farmer decision-making. However, the peasant as a complete risk avoider is probably as much a fiction as the risk-ignoring peasant. Total risk aversion precludes innovation, yet innovation can be shown to be a continuous although slow, process in peasant agriculture. Once a connection and dependence to an outside market has been effected, the peasant cannot afford not to innovate in response to changing prices, costs, or buyer standards, rising expectations, or developments among competition (Zinkin, 1971, p. 27).

Synthesis: A Conceptual Framework

The discussion in the previous sections of the chapter yields a number of general arguments which fit together logically to provide a conceptual framework describing the peasant man-land relationship. By no means comprehensive, nonetheless the framework includes several points of critical importance to the construction of normative land-use models which approximate the realities and purposes of peasant agriculture. They are summarized as follows.

Insofar as the peasant farm is a productive unit, its resources may be broken down into a set of production factors. When these factors are allocated most efficiently, profits are at a maximum. In static surroundings, peasant farms might be expected to be operating at or near peak efficiency--not because the peasant farmer is an exceptionally good decision-maker, but because he is reflecting a long process of trial and error. Under changing or fluctuating conditions, peasant farms are more likely to be in a state of inefficiency.

Analysis of the peasant farm as only a firm is incomplete, however, and can be misleading, especially as regards the nature and disposition of the labor force. The peasant farm is a social unit, consuming as well as producing. Because of the integrity of the household, family labor is, in fact, not a variable cost, but a constant and overhead one.

The objective of the peasant farmer is subsistence. This goal is not to be taken as the achievement of bare survival, but includes the meeting of physiological needs of food, fuel, clothing and shelter at acceptable levels, the discharging of obligations to society and the state, and the furthering of personal aspirations.

In an economic sense, the fixed cost of family labor, plus the requirements of non-working household members, may be equated with the cost of subsistence, the major portion of which is the cost of biological maintenance. As the cost of subsistence must be met regardless of the degree to which family labor is worked, there can be no advantage to withholding family labor from the farm (unless there are attractive outside work opportunities). An efficient farm, therefore, may use family labor freely to its limits in order to spread subsistence costs and thereby reduce as much as possible the average cost of production.

The achievement of subsistence is usually accomplished through a number of concurrent strategies, one of which is the allocation of resources between production intended for market exchange and that destined for home consumption. Market connections are a source of cash, for which there is a demonstrable need in peasant societies.

Within the context of subsistence, the ultimate purpose of peasant agriculture can be said to be profit maximization, although these are not profits in the capitalist sense. Profits may be calculated as useful production beyond subsistence--in other words, storeable, tradeable, or saleable production in excess of the cost of household maintenance and obligations. Profit maximization is subject to many constraints, a fact which has likely given rise to arguments for the existence of "subsistence mentality."

The major constraints to profit maximization stem from the peasant's need to insure his family's survival against possible adverse outcomes. This is done through the use of a historically tested "survival algorithm," which includes risk spreading through the mixing of crops. Flexibility within a survival algorithm--that is, ability to experiment, innovate and take risks--is probably a function of the relation of the stakes to the assets of the farmer (Zinkin, 1971, p. 26), as well as a reflection of personal inclination and the cultural and physical environment.

CHAPTER III

A NORMATIVE MODEL OF PEASANT FARMING

Introduction

In the previous chapter, it was contended that the peculiar nature of the peasant man-land relationship is the interdependent and inseparable association between the household and the land, composing a functional unit. The land depends upon household labor to bring forth its fruits, and, in turn, offers subsistence to the household.* The peasant farm system, with land and human resources varying by site, differs in its local expression. Realistic development models for peasant agriculture should allow for local differences in resources and surroundings, and should incorporate the peasant household-land association as a central feature.

The problem posed in this study is one of the efficient allocation of scarce resources. Mathematical programming provides a technique for solving problems of decision-making, where the goals and restrictions are definable by mathematical statements. The task of building a normative land-use model for peasant agriculture, therefore, becomes one of translating the problem of efficient farm resource allocation within the constraints and requirements of the subsistence peasant household-farm into a set of realistic mathematical relationships amenable to solution.

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*Land may also represent to the peasant such important intangibles as security and pride of ownership (Lowenthal, 1961).

Linear Programming

Mathematical programming is an operations research technique commonly employed by professional planners. Of the several mathematical programming techniques, linear programming (LP) is most widely employed. The essential characteristic of LP is that all relationships between variables are assumed to be linear, continuous, and additive. There is also a class of programming techniques where exponential and other non-linear relationships are dealt with. Other methods are integer programming, when the solutions require integer numbers, and dynamic programming, which solves for a series of optimal solutions over time (Tintner, 1971, p. 70). However, LP has the advantage of generally fewer data requirements, relative simplicity of model design, and speed in execution of solution.

As agricultural planning tools, LP models are extremely flexible and "can be formulated to accommodate all important variants of the individual farm and the economic and social organization of farms." (Heady, 1971, p. 18). In effect, any number of resource-use possibilities (or farm enterprises) on a continuum of intensity levels may be considered. Furthermore, all relevant parameters specifying limits and conditions to the problem may be included. LP was selected as the most practical and promising technique to develop the efficient peasant farming systems based upon local parameters proposed in this study.

The building of a LP model consists of fitting data and observations of reality to an a priori structure, consisting of a single objective function to be maximized (or minimized):

(1) maximize $f(Z) = R'Z$

where R is a vector of unit returns, and Z the vector of activity levels, subject to sets of inequalities or constraints

(2) $Z \geq O$

(3) $B \cdot Z \leq C'$

where B is a matrix of input-output coefficients,* and C the vector of resource limitations. This imposed structure naturally limits the number and scope of problems which can be treated through LP, and occasionally forces unreasonable distortions. On the other hand, fitting the model with data becomes a relatively simple task once the basic problem has been adapted to meet the demands of the programming format.

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*An input-output coefficient refers to the amount of a resource required to generate one unit of an activity (or product).

LP Models for Peasant Agriculture

Maximizing the Value of Production

In Western and Socialist agricultural planning, LP has become a standard tool. In the last decade, researchers have increasingly come to apply LP to agricultural problems in the Third World. The majority of such applications, however, deal with farms which are primarily commercial and Western in organization and orientation. The models which specifically treat peasant agriculture are few. Clayton (1964) reports on a LP study of a number of peasant farms in Kenya. The models developed are simple, but adapted to some of the singularities of peasant farming. Labor is considered as a free resource of fixed amount, rather than as a variable cost. The only other factor of production included is land. Thus, a typical model would be

(4) maximize $f(Z) = R \cdot Z$

where R is the vector of net prices per unit, and Z the vector of farm activity levels, subject to

(5) $Z \geq O$

(6) $B \cdot Z \leq C'$

where B consists of submatrices of yield coefficients (for the two annual growing seasons) and labor coefficients, while C contains subvectors of land and labor availability.

The assumptions inherent to the Clayton models are characteristic of most LP farm models: prices, input-output coefficients, and resource amounts are determined exogenously (i.e., they cannot be modified by interaction between variables). Further assumptions are that resource units are homogenous (any job may be performed by any member of the work force at the same cost in man-hour equivalents), and that production factors and activities are infinitely divisible (i.e., a solution may specify fractional amounts) and finite (i.e., all relevant restrictions and activities are included in the model).*

Heyer (1971), also working in Kenya, develops models similar to those of Clayton (1964), although more elaborate and realistic in detail. Crop activities are distinguished not only by species, but by time of planting as well. Some crop activities are further defined on the basis of alternative cultural practices. Different weeding strategies are included as well. Labor is treated with a set of constraints, each based on a critical period of labor demand in the agricultural year. Although the farmers are "semi-subsistence," Heyer assigns market values to all crops--both commercial, and those destined for home consumption.

Other researchers have designed LP models for peasant farms in Japan (Yajima, 1965), Costa Rica (García, 1968; and Bieber, 1970), and Jamaica (Peterson, 1970), to cite a few examples. These models all conform to the basic framework exemplified in the Clayton models--that is, there is a profit or revenue maximizing objective function, constrained by production factor supply. The models, by their attention to relevant detail, successfully overcome an earlier criticism by Joy (1967) of existing peasant LP models:

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*Although all LP textbooks set forth the principles, theory, assumptions, and mathematics of LP, Heady and Candler (1958) is an especially good source for further information, as they specifically treat LP in relation to agricultural problems.

> Matrices of the order of 200 x 200 seem to be necessary for the effective description of a "peasant" farm situation and it is hardly surprising that studies based on matrices of the order of 20 x 20 produce little insight or conviction. (Joy, 1969, p. 381)

The Problem of Risk

Generally, however, despite their relative sophistication, these models display several weaknesses. One of these is in the treatment of the problem of risk and uncertainty, a major determinant of peasant agricultural decision-making (Lipton, 1968). There are several approaches to the incorporation of risk considerations in LP models (Thompson, 1971, pp. 317-323). The simplest and agriculturally safest is the utilization of the pessimist criterion in which the model selects a revenue maximizing farm program assuming the worst possible outcome for each activity (considered the "maximin" or "minimax" criterion). Conversely, there is the optimist or "maximax" approach which bases decisions on the best possible outcomes. Between these two extreme approaches is the more complex and data demanding one of the expected value criterion in which consequences intermediate between best and worst outcomes and the likelihood of their occurrences are used to generate plans of maximum probable revenue.

None of these approaches are entirely practical or satisfactory for peasant agriculture. There are a number of reasons for this. One is the fact that most risk programming models--especially those using expected value criteria--require large amounts of historical and technical data to establish frequency curves of occurrences and the biological and economic consequences of each occurrence (Maruyama, 1972; Duckham, 1967, p. 77). Such data, difficult enough to obtain in places where detailed records are kept, are nearly nonexistent in areas of traditional agriculture. In addition, neither the minimax or maximax criteria encourage or even recognize the peasant farmer's varying willingness, ability and need to take risks.

Development of peasant agriculture is not possible with the overly cautious minimax approach, nor is it sustainable with the reckless maximax one. The use of expected values is unrealistic in that there is no such thing as an "average" year: in most years (that is, non-extreme ones), some crops will turn out worse than expected, others better. While in the long run such random deviations will tend to cancel each other out, the use of expected values for year to year planning yields results of questionable applicability and security to peasant farmers.

The peasant farm planning models of Clayton (1964), Heyer (1971), and others discussed above treat the problem of risk in several ways. One is the use of input-output and objective function coefficients which are assumed average or representative of the situation most likely to occur. In addition, Heyer (1971), identifying rainfall variability as the most important source of farmer uncertainty in her study area, devises programs for three output-effecting scenarios: "high," "low," and "average" rainfall.

This study proposes a different approach to the problem of hazard and risk. Recognizing the fact that every established farming community has devised a proven "survival algorithm," (Lipton, 1968) this study calls for the identification of the essential features of such an algorithm, and its incorporation into the proposed model as a set of explicit or implicit constraints. The resulting model will solve for revenue maximization after survival precautions have been observed. In other words, the model will attempt to duplicate local farmer criteria for dealing with risk. While this method will not necessarily yield the highest probable revenue possible under average conditions since it may be unduly restrictive, given the actual probability of outcomes, it possesses two advantages. First, plans which simulate farmer behavior stand a better chance of local acceptance; secondly, quantitative data requirements are far less than those demanded by the minimax, maximax, or expected value approaches--although qualitative information inputs may be greater.

Minimizing the Cost of Subsistence

In spite of the insight into peasant economic conditions displayed by previous peasant farm LP models, they may be criticized on the grounds that they take into account only the farm's production function. The approach taken is to maximize the value of production at market prices through the best mix of farm production activities subject to the limitations of resources. There is a fundamental weakness in such a planning strategy. Market prices are usually a reflection of extra-community--often international--processes. They seldom are an expression of local farm resource unit values (Janzen, 1973, p. 1213). Therefore, the assignment of market prices to items which are destined for farm household consumption (i.e., "subsistence" farming activities) is inconsistent with the programming goal of maximizing farm revenue through the most efficient use of resources.

The real value of a subsistence item is the result of a complex relationship between its desirability and nutritional worth, on the one hand, and its competitive bidding position vis-a-vis cash generating and other subsistence activities for farm resources, on the other. It follows, then, that household demand should be included in peasant planning models in order to describe a locally valid system for evaluating farm activities and resources. This concept may be stated from another analytical point of view: the cost of family labor is the cost of satisfying household demand. Implicit to the models discussed above is the assumption that the cost of family labor is constant, and therefore unimportant to the model. It is argued in this study that consumption as well as production is subject to optimization and should, as a result, enter any planning strategy.

The cost of family labor is largely that of feeding the family, or, more ideally, the cost of meeting or exceeding the family's set of calorie and nutrient requirements.* Minimization of this cost may be formulated as a general LP model:

(7) minimize $f(X) = C \cdot X$

where C is the vector of unit food costs, subject to

(8) $X \geq O$

(9) $A_1 \cdot X \geq R_1$

where A_1 contains each food's nutrient contents per unit weight, X is the vector of food purchase amounts, and R_1 is the vector of nutrient requirements for the group in question. This model is used routinely in certain livestock industries to devise least-cost feed mixes which supply all nutritional needs. Human diet design is made more difficult because of the practical necessity of rendering such diets palatable. As a result, any LP planned human diet should include the additional constraint

(10) $A_2 \cdot X \gtreqless R_2$

where A_2 and R_2 constitute a system of palatability, including such features as minimum and maximum amounts of certain foods or classes of foods, and fixed proportions between foods.

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*Hereafter, for the sake of convenience, the term "nutrient" will be taken to include calories.

Despite the difficulties in establishing parameters for expression (10), a number of human diet models have been designed, although at widely differing scales. Stigler (1945) was the first researcher to find a solution to the minimum cost diet problem, although not by LP methods. In his model, as in many later models, there is no explicit set of palatability constraints, although a certain amount of palatability is naturally ensured through a judicious initial selection of food choices. Smith (1959 and 1963) handles the problem of palatability constraints in detail, using empirical observation of eating habits as his data base. Both Smith and Stigler constructed models for a hypothetical American family. Examples of more specific applications of least-cost diet models are hospital menu planning (Liggett, 1965), a geography of the cost of dietary subsistence in Guatemala (Gould and Sparks, 1969), and a national food import and production program for Trinidad and Tobago (De Castro and Lauritz, 1967). There does not appear to be any LP diet model specifically designed for peasant households, although the need for such models would seem to be pressing where poor and malnourished populations are concerned.

The general LP model described in expressions (7), (8), (9) and (10) is not directly applicable to the peasant farm, in that not all foods consumed are purchased. In fact, the family diet can be supplied both by cash-crop production, which enables the purchase of food, and by direct consumption of farm production. Farm-grown foods are not free, however, because scarce resources are used, and revenue-generating production is forgone. The problem, then, is not only one of the optimum choices of food purchases, but becomes more complex with the necessity of an additional choice between food purchases and food production. The minimization of the cost of diet and the maximization of production revenues are two inseparable facets of the task of maximizing net farm revenues, reflecting the analytic need to view the peasant household-farm as one entity.

A Theoretic Normative Model

The model proposed in the present study attempts the incorporation of a least-cost diet within the farm revenue maximizing framework. This is done through the inclusion of food purchase, food production and consumption, and commercial crop production as choice variables, where the revenues generated by these are negative, zero, and positive, respectively. Constraining conditions are maximum limits on the supply of production resources, minimum nutrient intake levels, and various palatability and risk considerations. Stated algebraically, the model becomes:

(11) maximize $f(Z) = R \cdot Z = R^{1} \cdot Z_1 + R'_2 \cdot Z_2 + R'_3 \cdot Z_3$

(12) $R'_1 \cdot Z_1 \leq O$

(13) $R'_2 \cdot Z_2 = O$

(14) $R'_3 \cdot Z_3 \geq O$

where R_1 is the subvector of unit revenues coming from purchased foods, whose levels are contained in Z_1; similarly R_2 and Z_2, R_3 and Z_3 refer to subvectors of unit revenues and levels of farm grown and consumed crops, and commercial crops, respectively. Expression (11) is constrained by

$$(15)\quad Z \geq O$$

and

$$(16)\qquad B \cdot Z = \begin{bmatrix} O & B_{12} & B_{13} \\ O & B_{22} & B_{23} \\ O & B_{32} & B_{33} \\ -B_{41} & -B_{42} & O \\ (-)B_{51} & (-)B_{52} & O \\ O & B_{62} & B_{63} \end{bmatrix} \cdot Z \leq \begin{bmatrix} C_1 \\ C_2 \\ C_3 \\ -C_4 \\ (-)C_5 \\ C_6 \end{bmatrix}$$

where submatrices B_{12} and B_{13} are labor requirements per unit of farm-grown food and commercial crops, respectively; B_{22} and B_{23} are unit crop output coefficients of land; B_{32} and B_{33} are unit crop output coefficients of capital; B_{41} and B_{42} are nutrient contents per unit of purchased and farm-grown foods, respectively; B_{51} and B_{52} are palatability requirements per food unit; and B_{62} and B_{63} are risk precautions to be observed per crop unit. The submatrices of C contain values for the supply of labor (C_1), land (C_2), and capital (C_3); C_4 is composed of the set of total nutrient requirements for the household. C_5 and C_6 contain values which control diet palatability and acceptable risk levels, respectively.

There are a number of assumptions apart from those discussed in connection with the Clayton models. Unless specific provision is made, crop land on a given farm is considered a homogenous resource of uniform productivity. Land requirements per crop unit are unaffected by either amount or arrangement of crops grown. Likewise labor requirements per crop unit are assumed constant regardless of the level of production. If not otherwise defined, a man-hour can be rendered by any member of the labor force for any task.

The nutrient content of any portion of a food item is assumed to be constant for all equal weight portions of that food. Furthermore, it is accepted that an individual's total nutrient need is fixed, both in type and amount of nutrient, and that need can be calculated. Finally, it is postulated that food tastes do not vary within the household. Not considered in the model are the occasional differences between nutrient quality according to food source, the synergistic and antagonistic relationships between certain nutrients or food substances, and the variable and changing efficiencies of the human organism in nutrient uptake and utilization.

The Normative Model: A Summary

The model described in expressions (11) through (16) is theoretically valid in that the special peasant man-land association is taken into account. This is done by equating the cost of subsistence with that of labor. Food is the major item of the cost of subsistence. The cost of food, however, cannot be expressed in monetary units because of its various possible origins, whether from the farm or market; instead it must be expressed as an array of nutrient requirements. As nutrient requirements can be met by any number of food combinations at various costs in cash and resources, there must exist an adequate least-cost diet. While the cost of subsistence can be minimized, so also can the revenue output of the farm be maximized through an optimal combination of farm enterprises. Net revenues are at a maximum when costs are least and incomes greatest. Both the least-cost and greatest-income goals must be treated simultaneously, because consumption and production are interdependent on the peasant farm, having in common a single set of resources. Stated as a single LP problem, there can be found a set of farm and market activities which, by efficient use of farm resources, allows net revenues to be at a maximum, subject to the constraints of resource availability and household nutrient requirements.*

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*This LP problem is reminiscent of what Wolf identifies as the perennial problem of the peasantry, consisting "in balancing the demands of the external world against the peasants' need to provision their households." The problem is handled through the twin strategy of increasing production and curtailing consumption (Wolf, 1966, p. 15).

Testing the Model

An important step in the formulation of a model is its application to a real-world situation. Fitting the model to reality serves a number of purposes. It allows the examination of the workability of the model and the discovery and correction of any structural weaknesses or inconsistencies that might be present. Furthermore, the model can be assessed in terms of its flexibility in accommodating a range of actual field conditions. This empirical phase indicates both where it is necessary to refine the model further, as well as where the model exhibits superfluous detail. In this study, the normative model was fitted to a number of farms of differing resource characteristics in a peasant community of the Dominican Republic.

CHAPTER IV

THE STUDY AREA: FACTORS CONSTRAINING AGRICULTURAL PRODUCTIVITY

Introduction

Because a geographer's primary data come from observable patterns on the landscape, no model which attempts to describe man-land relations is complete until it is expressed in the context of a specific man-land system. Cultural and physical factors interact at every site to produce a particular set of constraints impeding complete realization of agricultural potential. For a useable prescriptive or normative land-use model, these constraints must be identified and incorporated.

The community of Entrada de Mao, a forty-square-kilometer _sección_,* located in the Dominican Republic's semi-arid northwest region, was chosen as a suitable site for the empirical phase of the study (Map IV.1). A principal reason for its selection was the fact that it is an area where small-scale peasant farming predominates,

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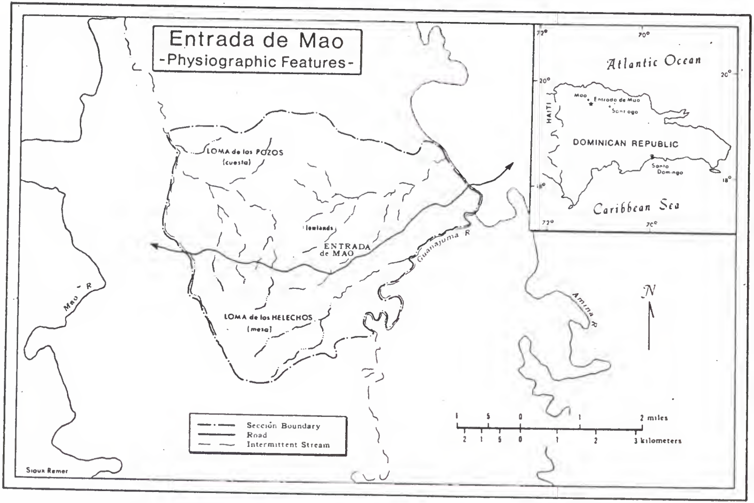
*A _sección_ is the smallest administrative unit found in the Dominican Republic. The _sección_ of Entrada de Mao lies within the municipality of Mao, which forms part of Valverde Province.


Entrada de Mao
-Physiographic Features-
LOMA de los POZOS
(cuesta)
lowlands
ENTRADA
de MAO
LOMA de los HELECHOS
(mesa)
Guanajuma R
Mao R
Amina R
N
Sección Boundary
Road
Intermittent Stream
2 miles
3 kilometers
Atlantic Ocean
Caribbean Sea
DOMINICAN REPUBLIC
HAITI
Mao
Entrada de Mao
Santiago
Santo Domingo
72°
70°
20°
18°
Sioux Remer

Map IV. 1

and where persistent poverty and population pressure (approximately 325 families) make agricultural planning desirable. In addition, there exist a number of studies which provide valuable background information and supplemental data for the area.*

Agricultural Constraints: Physical Factors

Climate

Peasant farming in Entrada de Mao lends itself well to the problem of allocative efficiency of agricultural resources for the reason that such resources are noticeably scarce. Located within the semi-arid piedmont bordering the prosperous plantations of the Yaque del Norte River floodplain, Entrada de Mao seems to offer little more than thorny forage for goats. That men have planted this land to crops more or less continuously from pre-Columbian times onward (Antonini, 1968) and managed to survive is a fact which the outside observer can scarcely believe.

Climatically, the area is characterized as Subtropical Dry Forest in the Holdridge life zone classification system (Holdridge, 1967). Natural vegetation consists largely of dense low thorn thickets, typified by such plants as Acacia scleroxyla Tuss., A. lutea Britton, Phyllostylon brasilensis Capan., Capparis gonavaiensis Helvig, and Guajacum officinale L. (Cucurullo, 1956, p. 535).

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*Description of the geomorphology of the sección is based on Antonini et al. (1967) and Antonini (1972). Soils information is based on field and laboratory samples gathered by Antonini in 1967. Discussion of agriculture and specific landscape features of the sección stems from the author's own field observations. Further detail on peasant agriculture in the region is provided by Antonini (1971).

Rainfall is slight, averaging 737.2 mm. per year,* of which 29 and 32 percent usually fall in the two rainy seasons of May-June (high-sun) and September-November (low-sun) respectively. However, average rainfall amount figures obscure the great variation that may occur from year to year. Over a thirty-year observation period, annual precipitation has been as low as 451.3 mm. (in 1967) and as high as 1190.5 mm. (in 1942). Furthermore, one or both of the rainy seasons may fail to materialize, or may arrive too early or too late to be of much agricultural use. Temperatures are continuously high, ranging from a mean monthly reading of 24.8° C in January to 29.8° C in August. Frost is unknown. The constantly high temperatures and generally clear skies contribute to the problem of aridity by causing high rates of soil moisture loss from evapotranspiration (Figure 1V.1).

Geomorphology and Soils

Of equal importance with climate, landforms and soils constitute the physical determinants for agricultural success within the sección.

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*Climatic data presented are observations from the meteorological station at Mao, located 9.7 kilometers from the center of the sección.

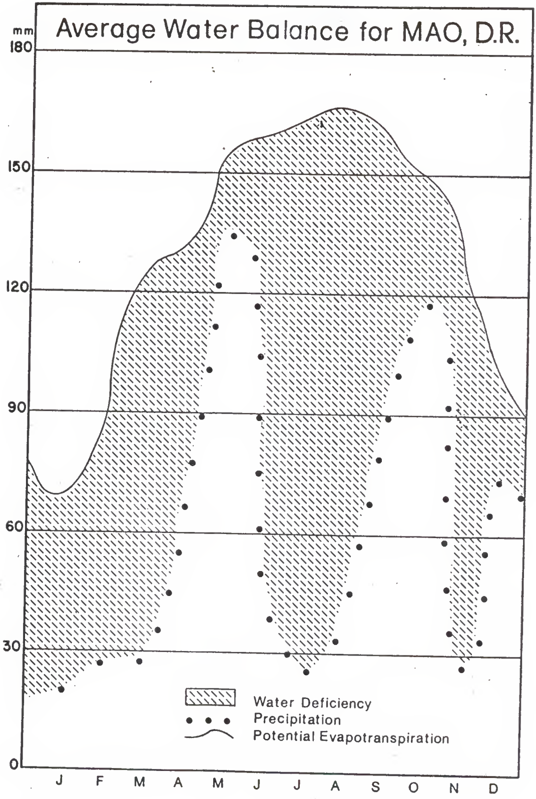

Figure IV. 1

Source: Antonini. (1968)

Entrada de Mao is located within the Cibao Valley, a major structural depression trending northwest-southeast the length of the republic, separating the Cordillera Septentrional on the north from the Cordillera Central on the south. Situated within a dissected piedmont region, much of the *sección* lies between cuestas, and the major portion of the farm-land rests on relatively weak, fossiliferous silts of the valley floor. Surficial material consists of pale, olive-colored, somewhat argillaceous calcareous silt (Antonini *et al.*, 1967, p. 8). The valley floor presents a hummocky appearance with low, rounded ridges and hills, and shallow vales. Slopes are gentle to moderate, although abrupt slopes are found bordering intermittent streams and the entrenched, meandering course of the Amina River. Deep gullying may be encountered anywhere. Elevations in this part of the *sección* range in height from approximately 90 meters above sea level in the Amina valley, to 211 meters on the interfluve between the Amina and Mao Rivers.

The southernmost portion of the *sección* is occupied by the north slope and summit of Loma de los Helechos, a mesa formed by resistant highly fossiliferous limestone overlying less resistant arenaceous siltstones. Calcareous colluvial material is found on the surface of the lower slope and adjoining valley floor (Antonini *et al.*, 1967, p. 8). In this part of the *sección,* the landscape becomes more rugged, with moderate colluvial slopes steepening sharply as they approach the mesa summit, which rises to a height of 403 meters.

There are few level spots, except on the mesa summit itself, and upon the occasional stream terraces found along the entrenched meanders of the Guanajuna River.

At the northern edge of the sección, the ground rises sharply once again to form the steep cuesta inface of Loma de los Pozos. The backface of the cuesta slopes gradually toward the Yaque del Norte River floodplain, which lies entirely outside the limits of the sección.

For the most part, the soils of the valley floor are medium-to-fine textured and deep. Soil alkalinity is high, surface pH ranging from 7.1 to 8.3 in samples taken from the area. While the natural fertility of these soils does not limit agricultural activity, soil texture is of some significance. The fine texture of the soils renders the area susceptible to sheet-wash and gullying wherever an exposed surface is encountered. The high clay and silt fractions also promote high soil moisture field capacities, allowing the more efficient use of limited rainfall.

In the northern and southern portions of the section bordering the valley floor, soils are shallower and contain greater proportions of coarse calcareous fragments. Agriculture is limited to the lower edges of these areas, where slopes are more gentle and soils are deeper. In these few locations, field capacities are likely to be lower than on the valley floor owing to the coarser texture of the soil, and the alkalinity reaction is stronger because of the higher content of calcium carbonate in the colluvium.

Available soil moisture, the result of the interaction between climate, terrain, and the mechanical and chemical properties of the soil, constitutes the prime physical limiting factor to local agriculture. The importance of this constraint is mirrored in the manner in which the *noroesteño* farmer perceives and categorizes his farm land as *haida* (slopeland), *llanos* (flatland), or *hoya* (hollow). *Haida* lands are least desirable because of shallow soils, increased runoff, and the resulting low amounts of available soil moisture. Conversely, *hoya* lands have deep colluvial soils and receive runoff from the surrounding slopes; they are therefore the most highly prized lands because of their greater moisture content. *Llanos* soils are intermediate in soil moisture content (and agricultural value) between the two extremes of *haida* and *hoya*.

Agricultural Constraints: Cultural Factors

Farming Practices

Crop farming is carried out on all three land classes in the valley, and on adjacent cuesta and mesa slopes. Apart from a few irrigated parcels along the Amina River, all cropping is of the dry-land variety, and is similar throughout the region in both structure and technique.

Typically, the agricultural year begins in July or August when *conucos** are prepared. If a new *conuco* is to be claimed from the thorn thicket, slash and burn techniques (*tumba*) are employed, while a second or third year *conuco* requires only the burning and cleaning off of the residue of the previous cropping season. *Conucos* are abandoned after one, two, or three years. The principal need for this seems to stem more from increasing numbers of pests, weeds, and diseases than from declining soil fertility. This task is usually performed by outside labor, as few farmers find it economical to own and maintain a team of oxen.

Crops typically planted at this time include corn, *Zea mays* L., and yuca, *Manihot eculenta* Crantz., as the principal row crops. Sweet potato, *Ipomea batatas* (L.) Lam., is sown as either a row crop or a random planting. From this time well into the middle of the rainy season, a variety of additional crops are planted between alternating rows of corn and yuca. These might include red beans, *Phaseolus vulgaris* L., sesame, *Sesamum indicum* L., peppers, *Capiscum* spp., onions, *Allium cepa* L., and tomatoes, *Lycopersicum esculentum* Mill. Squash, *Cucurbita maxima* Duchesne, and watermelon, *Citrullus vulgaris* Schrad., are planted at the edge of the field and their vines allowed to grow inward between the crops. A climbing

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*A *conuco* is the cleared field of the shifting cultivator.

plant, broad beans, Vicia faba L., may be planted at the base of any residual tree stump. Some papaya trees, Carica papaya L., are usually planted at random within the conuco. Bordering the conuco on all sides are bushes of pigeon peas, Cajanus cajan (L.) Millsp.

In late November or December, tobacco, Nicotiana tabacum L., is planted in rows between the standing crops. Occasionally, tobacco is planted in seed beds in November, and transplanted to the conuco in December. More commonly, it is planted directly in the conuco.

Corn and vegetable crops are picked from November to January, while the yuca and sweet potato harvests begin somewhat later. Some crops, such as yuca, sweet potato, okra and pigeon peas are harvested continuously over an extended period of time. Tobacco is picked regularly at fifteen-day intervals from late January to early June.

The high-sun rains (May-June) are not always sufficient in length to permit a second growing season, and many farmers forgo the second planting altogether. Because they are fast maturing, red beans and corn may be planted at this time. The crop calendar for the sección is presented in Appendix II.

Land Use and Production

While the choice of conuco crops and their distribution on the landscape may appear to be disorganized and unordered, there is in fact an underlying rationale. Antonini (1971) observes that the greater rewards from the higher potential hoya lands warrant practices and crops which yield the highest possible value per unit of land. Tobacco transplantation is therefore likely to be practiced, and land clearing is apt to be thorough. If a farmer's _conuco_ includes portions of different land classes, he may plant the higher value and more drought sensitive crops--notably tobacco, red beans, and peppers--on the best land, and lower value and hardier crops on the poorer lands. In this study area, such practices are likely to be encountered on the larger _conucos_. However, as most _conucos_ fall entirely within a single land class, and as a _conuco_ usually represents the only means of survival to a farmer and the major outlet for his labor, he will plant crops with the goal of obtaining as much production as possible from his land to the limits of his labor. To this reason may be attributed the fact that there is no general clear cut spatial variation by land class among crops and techniques observable in the study region.

While crop farming is the major activity of farmers in the _sección_, there is usually some supplemental livestock and fruit production. Goats and burros forage in the thorn thickets, while milk cattle feed on the guinea grass, _Panicum maximum_ Jacq., planted in abandoned _conucos_ and pastures. Yard animals include pigs and fowl. These are fed on household scraps, and the major portion of the corn and watermelon harvests. Purchased corn and rice hulls may supplement this diet. Some farmers keep bees.

Yards may possess an occasional fruit tree such as bitter orange, Citrus aurantium L., Barbados cherry, Malpighia puncifolia L., soursop, Annona muricata L., or sweetsop, A. squamosa L. There appears to be no significant quantity of food provided from hunting, fishing, or gathering.

Cash-Earning Activities

The landscape of the sección was radically transformed in the years following the Second World War when sisal, Agave sisalana Perrine, was introduced. A major cash generator for the area, sisal has been planted in much former conuco land. This effectively removes the land from the conuco-fallow cycle, since sisal bears for up to twenty years, and is exceedingly difficult to remove thereafter for purposes of field clearing. Worn-out sisal land is therefore all but useless for agriculture, except as rough forage.

The major source of income to the farmers of the sección generally comes from the sale of the tobacco crop. This is marketed as leaf tobacco, or is rolled into ropes and sold to outside buyers representing private companies or the government-owned Tabacalera. The price paid varies with the quality of the tobacco. Most tobacco sold from Entrada de Mao is of poor grade criollo quality, which earns the farmer RD$20.83* (1971) per hundredweight. No other conuco crop is sold, with the rare exception of corn. Sisal, the other important cash provider, sells for approximately RD$11.00 per hundredweight. This crop provides an especially useful source of cash in that it may be cut at any time, decorticated, and delivered to one of the community's several food stores in exchange for cash. Many farmers enter into a sharecropping agreement with owners of sisal fields, the most common of which is to harvest and decorticate the leaves in exchange for half the product. Although the returns scarcely compensate this back-breaking work (approximately RD$0.82 a day), the arrangement supplies a continuous source of ready income.

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*The Dominican peso (RD$) is set at par with the U.S. dollar.

From the farmer's point of view, both tobacco and sisal prices fluctuate in unpredictable fashion, the latter crop more than the former. Because they are imperishable, however, both may be held in expectation of more favorable prices, provided the need for cash is not too pressing.

Supplemental agricultural income may come from the sale of charcoal, a byproduct of the tumba (RD$50.00/cwt.), and the sale of livestock, eggs, milk, or honey. Occasionally, a household member may hire himself out as a day-laborer (peon) at RD$1.50 (1971) a day.

Labor and Costs

Agricultural expenditures may include the hiring of peones for the tumba or for the construction of a rancho (a lean-to used for tobacco curing), the payment for ploughing, or the purchase of axes, machetes, colines (a bush knife similar to a machete) or, infrequently, pesticides for the tobacco crop.

Apart from the use of peones in limited situations and the hiring of a ploughman, the labor needs of the conuco are supplied almost wholly by the adult and adolescent male members of the household. Thus, the size of the family labor force is a prime determinant of the level of farm output. Women and children are used only during periods of peak labor demand, notably the tobacco harvest. The tobacco harvest is also noteworthy for the fact that juntas (work groups) of up to thirty or forty men and boys will aid a particular farmer in several tobacco pickings during his harvest. In exchange, the farmer will reciprocate by donating one man-day of tobacco picking for each man-day contributed.

Conuco related tasks performed by the household include clearing, planting, weeding (usually two to six times during the tobacco season), and harvesting. Other agricultural demands on the household include rancho construction, and the watering and feeding of animals. The latter task is performed by women and children.

Farming technology is simple and age-old. Except for the use of oxen for ploughing, all tasks are man-powered. Tools are few--axe and machete for land-clearing, dibble-stick (or big toe) for planting, machete and colín for weeding and harvesting. The timing of major undertakings and the methods employed (the "survival algorithm") are based on long experience and belief and are part of the cultural traditions of the inhabitants of the region.

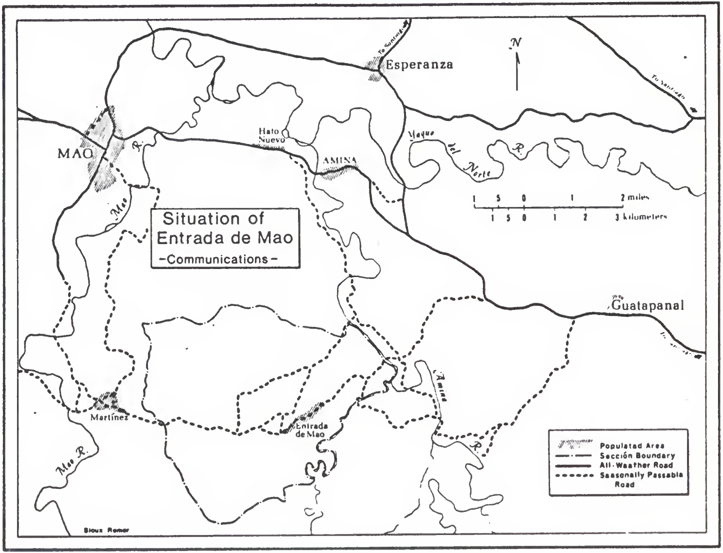
Land Tenure

Land tenure arrangements in the *sección* vary, and have little immediate effect on farm structure and technology. A *conuco* may either be owned by the farmer, or occupied by him with or without the owner's consent--which may be formal or tacit. Tenancy agreements involving rent or sharecropping are rare. The only apparent difference in land use between owners, on the one hand, and tenants and squatters, on the other, is that the latter group are not likely to plant land to sisal, owing to the time lag between land and labor investment and income returns (two to five years before the first cutting) coupled with the uncertainty of the future of their occupancy.

Communications

Limiting factors on farm potential thus far have been identified as the restraints presented by physical site characteristics within the cultural context of agricultural technology and custom. Another dimension must also be considered--the restrictions posed by the geographical situation of Entrada de Mao (Map IV.2). Although the center of the community lies only 9.7 kilometers from Mao, the provincial capital, and 32 kilometers from Santiago, the nation's second largest city, it suffers from a significant degree of isolation.

Communications with the outside world are tenuous. Roads


Situation of
Entrada de Mao
-Communications-
N
To Santiago
Esperanza
To Santiago
MAO
R.
Hato Nuevo
AMINA
Yaque del Norte R.
1 5 0 1 2 miles
1 5 0 1 2 3 kilometers
Guatapanal
Mao R.
Amina
R.
Martínez
Entrada de Mao
Mao R.
Populated Area
Sección Boundary
All-Weather Road
Seasonally Passable Road
Sioux Romer

Map IV. 2

leading into the sección are little better than trails and are liable to become impassable for weeks at a time during the rainy season. Road distances to the two cities of Mao and Santiago (the regional markets) vary according to route chosen: it is 38 kilometers to Santiago by fording the Amina River, or 61 kilometers via Esperanza (the latter route being somewhat more reliable than the former); Mao lies 19 kilometers via Hato Nuevo, or 12 kilometers via Martínez. Entrada de Mao is located south of the main lines of communications in the Yaque del Norte valley, and roads into the sección are essentially dead ends. There is no regularly scheduled transportation service into or out of the community, the only links for the sección being provided by two locally owned pickup trucks which are used for public transport and produce carriers, a few motorcycles,as well as the common-place horse and burro. External links are provided by trucks which carry in goods for local sale, and which carry out sisal, tobacco, and charcoal.

Because of the uncertainty of access to outside markets, agricultural cash earning activities are limited to nonperishable items. Locally produced food crops are not sold within the sección for the simple reason that nearly every household is harvesting the same crop at the same time. Surpluses are often disposed of as gifts, an important feature of community life. Out-of-season food staples must be provided from the outside, and are expensive because of transportation costs. A surprising variety of foods is sold in community food stores.

Diet

Notwithstanding the apparently wide selection of foods available for purchase, the ordinary diet of the *campesino* is monotonous. Meals number two or three a day, the principal one consisting typically of rice and red beans, or spaghetti and tomato sauce, or yuca, or sweet potato, and coffee. Children, as well as some adults, drink milk. The standard evening meal is a plate of yuca or sweet potato, and coffee. To this set of foods may be added a number of supplemental items which vary according to financial status, and personal taste--for example, plantains, sesame, or eggs. In season, additional fruits and vegetables, such as pigeon peas, mangoes, and oranges are eaten. Meat is consumed with variable frequency, but two to four times a month appears to lie within the normal range. That such diets--typical of most rural Dominicans--are substandard and conducive to ill health is borne out in a recently conducted national dietary and nutritional survey (Sebrell, King, Webb *et al.*, 1972).

Conclusion

Attempts to increase farm productivity in Entrada de Mao must take into account the numerous constraints which delimit the area of possibilities within which improvements can be made without major innovation. Some constraints vary spatially within the *sección*, others are uniform for the entire community. Spatially varying constraints of note are physical site characteristics and size of the family labor force in relation to farm size. These two factors are linked by locally prevailing technology. Farm activity is further restricted by the difficulties of access to the outside world, as well as the cultural and economic need for such access, especially as a source of locally and seasonally unavailable food. In the following chapter, models of several individual peasant farms in Entrada de Mao will be constructed which reflect the agricultural constraints which have been identified and discussed above.

CHAPTER V

THE STUDY AREA: FITTING THE MODEL TO THE FARM

Introduction

In this study, it has been argued that agricultural land-use planning should reflect the concept of spatially varying farm resources within the matrix of a culturally determined man-land relationship. Each place possesses a certain agricultural potential, determined partly by quality and quantity of resources, and partly by the needs, goals, and technology of the farmers who make the decisions concerning land use. In order to evaluate and bring about the realization of local agricultural potential, it is therefore necessary to consider both the nature of local farms and their resource bases. In designing individual farm models for Entrada de Mao, this approach was followed.

Areal Classification of Resources

In 1967, a team of scientists carried out an exhaustive survey of physical resources in the Northwest Dominican Republic for the purpose of dividing the region into "multi-variate areas of uniform agricultural productivity" (MVAUAPs) (Antonini *et al.*, 1967). These multi-variate areas were devised and delimited from factor analyses of three sets of variables relating to site attributes of soil, land surface, and micro-climate. Each site was then classified on the basis of pedological, topographical, and micro-climatic limitations placed on its agricultural potential and those sites showing similar patterns were grouped into MVAUAPs.

Such resource inventories and subsequent areal classifications are a necessary preliminary step to rational regional agricultural planning. A logical next step is to determine and measure the agricultural potential for each MVAUAP within local contexts of culture, technology, and economics. Data collection procedures in the present study were designed to conform to this end.

Data Collection

Field work for this study was conducted by the author in the period December, 1971-February, 1972. Objectives of the field experience were twofold: firstly, to observe the realities of peasant life in one locality--Entrada de Mao--and incorporate these findings into farm models derived from the theoretical model of optimum agricultural productivity; secondly, to gather specific data relating to peasant farms with which to calibrate the farm models. The first objective was approached through conversations, observation, and participation. The second objective called for a process of structured interviewing at selected farms with the use of a prepared questionnaire (Appendix I). Data obtained included information on crops, land and labor input-output coefficients, agricultural techniques, risk aversion practices, physical characteristics of the family, household expenditures, foods eaten, and dietary preferences.

A limited number of farms were selected for study. Such a case study approach--which is an alternative to the large-scale regional survey--is possible in areas where farms are largely homogeneous. Clayton (1964, p. 81) states that homogeneity among peasant farms is to be expected in uniform physical resource regions where land and labor are the only factors of production, and where the absence of machines tends to equalize man-hour productivity. The possible range of variation of farm organization is thus limited. This situation would seem to apply to peasant farms in Entrada de Mao, and their similarity to one another is apparent by examination of agricultural census data for the sección (Sexto Censo Nacional Agropecuario 1971).*

Methodology for the selection of farms for in-depth study was suggested by Clayton (1963) and (1964) who maintains that, in many areas, a peasant farm may be fairly accurately defined by its land to labor ratio (Clayton, 1964, p. 81). In the present instance, farms qualifying for case study were identified as farms falling within the modal class of peasant labor force/conuco size ratios in the section--that is, farms having a proportion of between 0.10 and 0.19 workers per tarea of conuco (Figure V.1). Final choice of farms from this class ("modal farms") was made with the advice of the local government representative (the alcalde) and local farmers, following a reconnaissance survey.

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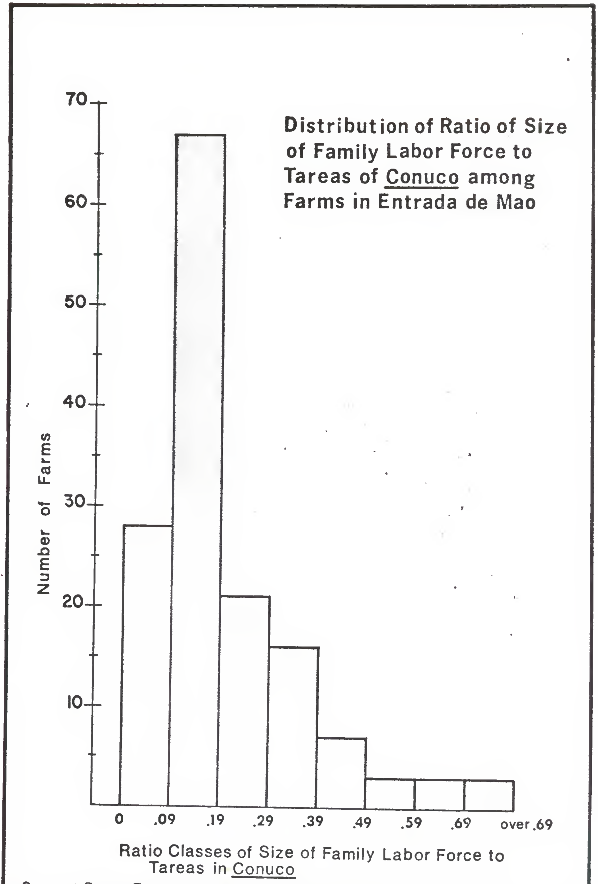
*For example, of the 182 farms in the sección, 162 could be inferred on the basis of census data to be peasant holdings: that is, farms which were nonmechanized, and which had no irrigated lands. Ninety-eight percent of peasant farms reported growing tobacco as a cash crop; 90 percent were exclusively family-worked, 95 percent by 1 to 3 household members, while female members worked on only 10 percent of these. Conuco size varied only slightly among peasant farms: 89 percent were between 5 and 24 tareas in extent. (1 tarea = 1.644 acres or 629 square meters.)

If the man-land ratio is held constant among farmers of similar organization within a culturally defined region, the major determinant of farm production becomes physical site quality. Therefore, in order to estimate the spatial variation in agricultural potential within the sección, five modal farms from agriculturally important MVAUAPs were selected for modeling and analysis. Map V.1 delimits the MVAUAPs of the sección and identifies the location of each of the modal farms.

Model Design

Seasonality

The empirical farm models resemble the theoretical model, but include the important dimension of time. Time of year emerged as a variable of critical importance to the agricultural productivity of the sección for several reasons. Diet composition varies through the year because of the changing availability of food items. This is

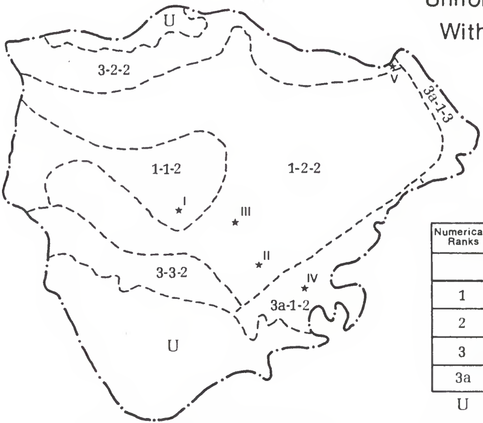


Distribution of Ratio of Size of Family Labor Force to Tareas of Conuco among Farms in Entrada de Mao

Source: Sexto Censo Nacional Agropecuario, 1971

Figure V.1

Multi-Variate Areas of Uniform Agricultural Productivity With Location of Modal Farms in Entrada de Mao



—·— Sección Boundary
- - - - MVAUAP Boundary
★ Modal Farm

Numerical Ranks	Variables		
	soil	land surface	microclimate
1	good	level	wet
2	intermediate	rugged	moist
3	poor	high relief	dry
3a	poor due to drainage; applies only to alluvial soils		

U unclassified

EXAMPLE:

3a-1-2 poorly drained alluvial soil on level surface with moist climate

MVAUAP: Multi-Variate Areas of Uniform Agricultural Productivity

Sioux Remer

Map V. 1

true not only for perishable fruits and vegetables, but for other food crops as well, owing to the limited technology and capacity for food storage. In addition, market prices change regularly from season to season. Any model which is designed to simulate annual diets is therefore obliged to consider time. In the present study, time was considered by dividing the year into trimesters (January-April, May-August, September-December), which approximate the natural divisions of the agricultural calendar--viz. the major harvest season, the optional secondary corn and red bean planting and harvesting season, and the major planting season. Each food purchase or food crop growing activity was then labelled as to the trimester of its availability, the assumption being that it could not be stored into the following trimester.* In like manner, sets of nutrient constraints were included for the three trimesters, so that the labelled food activity could contribute only to meeting the nutrient requirements of the appropriate trimester.

Time is also important in the disposal of labor. Because each farm activity has a specific place in the agricultural calendar, labor demands can change dramatically during the year. To account for this, family labor availability and demand were included separately for each month of the year in the model.

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*Exception to this assumption was made for food crops harvested at the extreme end of a trimester. These were considered available in the subsequent trimester.

Finally, the conuco itself exhibits a changing composition of crops throughout the year. Some crops remain in the ground the entire year, while others are planted and harvested in two or three months. In the model, land requirements per unit amount of crop were labelled as to trimester(s) of occupancy to permit the greatest efficiency of use of cropland space during the agricultural cycle.

Farm Activities

The basic farm unit treated in the LP models is the conuco. The models attempt to maximize farm revenue through manipulation of the conuco crop assemblage. Crops considered in the individual farm models are those actually grown on the conucos during the study period (September, 1970-August, 1971). In addition, one proposed cash crop innovation--sunflower--was included. Data on the latter cropwere obtained from the agricultural experiment station at nearby La Herradura (DeCock, 1972). Conuco crops may be divided into cash crops and food crops, the categories being mutually exclusive on the farms surveyed. Any crop which may be grown twice in the year (i.e., corn, red beans or sunflower) is treated as two separate growing activities.

Sisal cultivation, a non-conuco cash-earning activity, is also considered in the model. Sisal growing, harvesting, and decorticating are major sources of cash and labor utilization in the region, and are therefore included as a set of activities. Because of the frequency of the sisal harvest (once every four months) and its flexibility as to the month of cutting, the sisal grower has a choice between three annual cutting cycles. These are entered into the model as three activities. In addition, the sisal grower may have his crop harvested on a sharecrop basis. This too, is entered as a choice variable. Finally, a farmer or his sons may harvest and decorticate another's sisal crop for half the proceeds. As this may be done in any month of the year, twelve additional activities must be evaluated in the model.

A potential innovation--ropemaking--was included as a choice variable to test its viability in the section as a labor opportunity. At present, all sisal from the *sección* is sold without further processing. Labor input requirements were gathered in the outskirts of Santiago, where ropemaking is a common cottage industry. Finally, because of the choices between selling sisal as fiber, further converting it into rope, or buying sisal for ropemaking, sisal selling and buying activities were required in the model.

Entering the model in fixed amounts are home-grown but non-*conuco* farm food items (i.e., yard fruits, and animal products) as well as *conuco*-grown crops which were not easily amenable to treatment by the model for one reason or another. These include crops which have specialized and restricted location in the *conuco* (i.e., broad beans by tree stumps, pigeon peas on the *conuco*'s perimeter, or plantains in moist pockets of soil) or crops which occupy strata different from that of the main set of *conuco* crops, and which therefore compete for different space (i.e., watermelon and squash, whose vines grow over and between other crops, and papaya trees, which occupy the overstory).

Risk Aversion

In order to produce farm plans which are in harmony with the prevailing survival algorithm, model provision should be made for the inclusion of risk aversion procedures.

In Entrada de Mao, the greatest source of agricultural uncertainty is rainfall variability. Subject to a mean monthly rainfall variability coefficient (V)* of 85 percent, the *sección*'s normally marginal dry land crops are constantly threatened by failure stemming from drought. Excessive rainfall may also cause occasional crop failure owing to flooding, lodging or waterlogging. In addition, rainfall variability may indirectly result in crop destruction through the environmental influence on crop pests. Market price variations present further occasions of risk, although the ability to store the major cash crops of tobacco and sisal partially alleviates this problem.

The threat of crop destruction by drought is handled in at least

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$$V = \frac{\sum_{i=1}^{12} \frac{(\sigma_i)}{(x_i)} \text{ x } 100 \text{ percent}}{12}$$

where σ_i = standard deviation in rainfall distribution in month i, and x_i = mean rainfall in month i.

two ways by the farmers of the region. The first lies in the choice of crops and farming techniques. Historical experience has left the farmer with a set of crops which are reasonably safe to plant, given local environmental conditions. These crops may be ranked on a scale of riskiness--such crops as yuca being perceived as "safe" in almost all years, while corn is always a considerable gamble. Weighted against the risk involved is the potential return of the crop, higher returns justifying increasingly riskier crops. As with crops, so too the commonly employed agricultural techniques are those which have proved themselves effective in providing acceptably consistent returns year after year. The model, by its consideration of only those crops and techniques presently used in the study area (with the exception of sunflower and ropemaking), duplicates the first method of risk aversion.

The other method of risk aversion which local farmers practice is risk spreading through the planting of a wide variety of crops. Certain crops, because of similar patterns of moisture requirements and like susceptibilities to drought, tend to fail in the same years. Drought-sensitive crops may be grouped together according to their tendencies to fail jointly in a given year, and wise farmers avoid committing all of their land resources to any one group. Instead, they try to allocate land to crops from the various risk groups in order to reduce the probability of total crop failure. Therefore, for example, a farmer will seldom plant more than half his conuco to tobacco, or to peppers, sesame and tomatoes, although these are all attractive and rewarding crops when all goes well.

The strategy of risk aversion through the spreading of land resources over a number of crops from different risk groups is incorporated into the model as a set of constraints

$$(1) \quad \begin{matrix} B_1 \\ \vdots \\ B_i \end{matrix} \cdot\cdot \quad Z \leq \begin{matrix} C_1 \\ \vdots \\ C_i \end{matrix}$$

where $B_1 .. B_i$ are vectors containing unit land requirements (that is, the inverse yield) for drought-sensitive crops, which are organized into groups 1 .. i on the basis of their mutual tendencies of co-failure; Z is the vector of crop output levels to be specified by the LP solution of the model; $C_1 .. C_i$ are maximum amounts of land to be allowed any of the co-failure groups. It should be emphasized that this constraint set does not minimize the risk of crop failure due to drought--rather, it sets a level of risk acceptance (C) which may be adjusted upward or downward according to personal farmer preference.

Farmers interviewed showed a tendency to perceive a need to balance land resources among at least three major crops--tobacco, yuca, and sweet potatoes. There was some confusion in assigning other crops to groups, a situation highly understandable in light of the complexity of grouping crops with similar histories of failure. The problem of grouping is made difficult by the varying lengths of time different crops are in the ground and the assortment of contrasting temporal moisture requirement patterns. Thus, as an example, Crop A, planted in October and needing moisture in every month, may fail at harvest time in December, while Crop B, planted in December and requiring moisture at time of germination, will also fail in December. The fact that both crops have similar histories of failure is obscured by different planting dates, and may not always be readily apparent.

Another variable which may cause crops to have coincidental but unapparent rates of co-failure is the frequency of certain weather sequences in a given climatic regime. For example, a dry March may be statistically associated with a wet February or perhaps a dry October. Whether the association is only a statistic one, or actually reflects a functional link, the effect is the same: Crop C and Crop D, requiring March and October moisture respectively will have a high probability of co-failure, even though they do not share the same growing season.

In order to derive and isolate groups of crops having high rates of co-failure, the following procedure was employed. Using the 29-year monthly precipitation and temperature records for the Mao station and soil parameters from samples taken in Entrada de Mao, monthly soil water budgets were generated for the period January, 1942-December, 1971 for soil depths down to one meter. Superimposed on this record was the crop calendar, together with information on crop rooting depths. Applying data on individual crop resistance to soil moisture pressure at permanent wilting point, together with number and yearly arrangement of the months of moisture required by a crop, individual crop failure histories could be reconstructed through simulation. Crops which had a failure rate of 15 percent or greater (that is, four or more failures in 27 years) were deemed drought-risk crops, and were assigned to co-failure groups by constructing a Pearson Product Moment correlation matrix to identify drought-risk crops having high frequencies of co-failure. The groups are shown in Table V. 1.

Farm Constraints

Row vectors of the LP models comprise input-output coefficients relating to the series of choice variables, and constraints which act to restrain or compel levels of production. These constraints constitute sets regulating risk (previously discussed), labor and land supply, nutrient requirements, palatability considerations, and fixed, minimum, or maximum output levels of selected activities.

Labor supply

Labor supply is treated as having twelve components--one for each month of the year. Input coefficients--expressed as man-hour requirement per hundredweight of choice variable output--were obtained from interviews. Monthly man-hour availability was calculated on the basis of an eight-hour day for every full-time conuco worker.

TABLE V.1 - High-Risk Crop Groups Having a High (≥ 67%) Probability of Co-Failure, and Trimesters of Land Occupance.

	Trimester		
Crop Groups	I^{a}	II^{b}	III^{c} *
Group A:			
Second-Rains Red Beans	x	x	-
Second-Rains Corn	x	x	-
Yuca (January Planting)	x	x	x
Group B:			
Sweet Potato	x	(x)	x
Eggplant	x	x	x
Plantain	x	x	x
Group C:			
First-Rains Red Beans	x	-	x
First-Rains Corn	-	-	x
Peppers	-	-	x
Tomatoes	-	-	x
Sesame	-	-	x
Okra	-	-	x
Group D:			
Tobacco	x	x	-
Group E:			
First-Rains Sunflower	x	-	x

*a January-April, b May-August, c September-December

Sundays and holidays were idle. Subtracted from the monthly man-hour total were significantly time-consuming non-conuco related tasks (e.g. water-fetching and school attendance), as well as conuco related jobs which could not be expressed easily in terms of hundredweight of individual crop or sisal activity (i.e., land clearing and weeding).

Land supply

Actual size of the model conuco sets the limit of land availability. In the model, land may be occupied over three trimesters, each trimester relating to a row vector of land input coefficients. Data for crop yields per tarea were not directly obtainable from interviews. Because of intercropping, farmers were not always familiar with this monocultural concept. To calculate an areal crop yield,* it was necessary to use a deductive process whereby the row yield of a crop in a particular conuco was multiplied by the number of rows that could be held in one tarea of the conuco if the crop were a pure stand. Row yield data were obtained by interview, while row-spacing figures were those recommended by a government handbook for peasant farmers (Instituto Superior de Agricultura, 1971). This technique of extrapolation appeared to give fairly accurate results, and the yields thus calculated compared closely with the farmers' own estimates of areal yields.

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*For the purposes of model flexibility and to increase the number of alternatives, it was considered important to calculate areal crop yields of hypothesized pure stands of individual crops, rather than a conuco yield of a set of crops in fixed proportions to one another.

Nutrient requirements

Nutrient values of foods were taken from standard food composition tables published by United States Department of Agriculture (Watt and Merrill, 1963) and INCAP (Leung and Flores, 1961).* Nutritional arrays were expressed per hundredweight of food as purchased or harvested, thereby taking into account inedible portions of the food item. Allowance is not made for nutrient losses in cooking and preparation, for which there is no standard method of calculation.

While a human need can be demonstrated for at least forty nutrients, requirements for eleven nutrients (including calories) were selected as constraints in the model. These are nutrients for which Recommended Dietary Allowances (RDAs) have been set by the National Research Council (1968). Although RDAs also exist for the nutrients sodium chloride and potassium chloride they were excluded from the constraint sets on the assumption that the need for these two items would be met automatically in any diet because of their generally great abundance in the foods included in the model. Nutrient requirement sets were calculated for each household by trimester using techniques presented by the National Research Council (1968). Variables considered when estimating individual RDAs include age, sex, level of activity, pregnancy and lactation. As with food composition figures, RDAs can vary among individuals, not only because of individual biological differences but also as a result of such RDA-increasing factors as intestinal parasites which, it is reported, infect some 70 percent of the rural Dominican population (El Caribe, 1972).

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*It should be cautioned that the nutritional composition of a food can vary considerably according to such influences as soil quality where grown, degree of maturity at harvest and length of storage--to name only a few. Figures in food composition tables are based on statistically tested samples, and can therefore be accepted as representative of the food as a whole, although not necessarily for food from one locality.

Palatability requirements

Sets of palatability constraints were formulated, using a number of sources including interview data, informal observation, a nutritional survey of the Dominican Republic (Sebrell, King, Webb et al., 1972), and a popular Dominican cookbook (Bornia, 1967). The task of establishing these constraints is a difficult yet an important one. Because it is likely that each concession to palatability will detract from optimality by increasing dietary costs, palatability constraints should be applied sparingly. The decision as to the degree of importance palatability should play in diet determination is a subjective one on the part of the model-builder: inclusion of every household food dislike or preference would naturally result in a replica of current diet, while, conversely, no concession to palatability would likely produce a distasteful and unacceptable collection of foods.

The questioning of informants as to their conception of an ideal diet revealed a certain discernible pattern. A "good" meal would include yuca or sweet potatoes, rice, meat, milk and coffee, as basic items. Some of these foods require ancillary foods as cooking aids or condiments: yuca and rice are cooked with oil or lard; rice is served with beans (which are perceived as a sauce) which, in turn, are cooked with onions, garlic, and oil or lard; coffee is sweetened with sugar; if spaghetti is eaten, it is accompanied by tomato sauce. This ideal diet can be expressed in two types of constraints: one type specifies minimum levels of ideal food items; the second type governs the proportions of ancillary foods to basic foods. Minimum levels of yuca, sweet potatoes, rice and coffee were set by actual household intakes, the reasoning being that demand is relatively inelastic for these foods, as they are cheap enough to allow satisfactory amounts of consumption. Lower limits on milk and meat were established by taking as the norm the highest consumption levels encountered among the households. Constraints regulating proportions were derived from a cookbook (Bornia, 1967), and from interview data. While no claim is made for the completeness of this constraint set (e.g. some regularly eaten foods, such as olives and salt, are excluded because of their insignificance in total annual cost), it is felt that acceptable and appetizing least-cost diets can be generated with this information.

Finally, certain foods, because of their relatively high nutrient-to-cost ratio, tend to enter least-cost diets in unreasonable amounts. Upper limits on such foods should be set to maintain palatability. Unfortunately, the identity of these foods can only be discovered after several trial LP solutions to the model. In this study, foods which were prevented from entering the diet at excessive levels were sesame, oranges and lard.

The Farm Models

The original theoretical model presented in Chapter III was modified to meet conditions prevailing on farms in a specific locality. The revised revenue maximizing models for peasant farms in Entrada de Mao follow. Defining terms:

R = a 17 x 1 vector of subvectors containing revenue values per cwt. of choice variable of vector Z, subvectors of which are

$Z_{1,1}$ = foods purchased in Trimester I (January-April)
$Z_{2,1}$ = " " " " II (May-August)
$Z_{3,1}$ = " " " " III (September-December)
$Z_{4,1}$ = food crops harvested in Trimester I
$Z_{5,1}$ = " " " " " II
$Z_{6,1}$ = " " " " " III

$Z_{7,1}$ = tobacco growing

$Z_{8,1}$ = sunflower growing

$Z_{9,1}$ = sharecropped sisal (farmer as sharecropper)

$Z_{10,1}$ = " " " (farmer as owner)

$Z_{11,1}$ = sisal growing (grown and cut by farmer)

$Z_{12,1}$ = ropemaking

$Z_{13,1}$ = sisal selling

$Z_{14,1}$ = sisal buying

$Z_{15,1}$ = food crops and non-conuco produce entering in fixed amounts in Trimester I

$Z_{16,1}$ = food crops and non-conuco produce entering in fixed amounts in Trimester II

$Z_{17,1}$ = food crops and non-conuco produce entering in fixed amounts in Trimester III

B = a 13 x 17 technical matrix of submatrices containing input coefficients related to cwt. unit output of Z, the product of $B \cdot Z \cdot$ being constrained by vector C, the subvectors of which are

$C_{1,1}$ = monthly household labor availability

$C_{2,1}$ = conuco land availability by trimester

$C_{3,1}$ = conuco land availability for risk groups by trimester

$C_{4,1}$ = female household labor availability

$C_{5,1}$ = upper limits on sisal activities

$C_{6,1}$ = sisal output equals sisal input

$C_{7,1}$ = household nutrient requirements for Trimester I

$C_{8,1}$ = " " " " " " II

$C_{9,1}$ = " " " " " " III

$C_{10,1}$ = palatability considerations in Trimester I

$C_{11,1}$ = " " " " II

$C_{12,1}$ = " " " " III

$C_{13,1}$ = fixed input levels of selected items

the model expressed

$$(2)\ \text{maximize } (f)Z = \left[R'Z = R_{1,1} \cdot\cdot\ R_{1,17}\right] \cdot \begin{bmatrix} Z_{1,1} \\ \vdots \\ Z_{17,1} \end{bmatrix}$$

or, eliminating subvectors of zero value

$$(3)\ \text{maximize } (f)Z = \left[-R_{1,1} \cdot\cdot\ -R_{1,3},\ R_{1,7},\ R_{1,8},\ R_{1,12},\ R_{1,13},\ -R_{1,14}\right] \cdot \begin{bmatrix} Z_{1,1} \\ \vdots \\ Z_{3,1} \\ Z_{7,1} \\ Z_{8,1} \\ Z_{12,1} \\ \vdots \\ Z_{14,1} \end{bmatrix}$$

which organizes farm and household activities in such a way that annual revenues from food purchases in all trimesters (negative revenues), tobacco growing, sunflower growing, ropemaking, sisal selling and sisal buying are at a maximum. Limiting the model are the constraints

(4) $Z \geq 0$

(5) $$B \cdot Z = \begin{bmatrix} B_{1,1} & \cdot\cdot & B_{1,17} \\ \vdots & & \vdots \\ B_{13,1} & \cdot\cdot & B_{13,17} \end{bmatrix} \cdot \begin{bmatrix} Z_{1,1} \\ \vdots \\ Z_{17,1} \end{bmatrix} \leq \begin{bmatrix} C_{1,1} \\ \vdots \\ C_{13,1} \end{bmatrix} = C$$

or, eliminating zero value terms

(6) $$\begin{bmatrix} B_{1,4} \cdot\cdot\ B_{1,9}, & B_{1,11}, & B_{1,15} \cdot\cdot\ B_{1,17} \end{bmatrix} \cdot \begin{bmatrix} Z_{4,1} \\ Z_{9,1} \\ Z_{11,1} \\ Z_{15,1} \\ \vdots \\ Z_{17,1} \end{bmatrix} \leq \begin{bmatrix} C_{1,1} \end{bmatrix}$$

which prevents monthly man-hour labor inputs for conuco crops, sisal harvesting and processing, and ropemaking from exceeding monthly man-hour availability;

(7) $$\begin{bmatrix} B_{2,4} \cdot\cdot\ B_{2,8}, & B_{2,15} \cdot\cdot\ B_{2,17} \end{bmatrix} \cdot \begin{bmatrix} Z_{4,1} \\ \vdots \\ Z_{8,1} \\ Z_{15,1} \\ \vdots \\ Z_{17,1} \end{bmatrix} \leq \begin{bmatrix} C_{2,1} \end{bmatrix}$$

which prevents trimester land inputs for conuco crops from exceeding the amount of land available;

(8) $$\begin{bmatrix} B_{3,4} \cdot\cdot\ B_{3,8}, & B_{3,15} \cdot\cdot\ B_{3,17} \end{bmatrix} \cdot \begin{bmatrix} Z_{4,1} \\ \vdots \\ Z_{8,1} \\ Z_{15,1} \\ \vdots \\ Z_{17,1} \end{bmatrix} \leq \begin{bmatrix} C_{3,1} \end{bmatrix}$$

which prevents trimester land requirements of any risk group from exceeding a given amount of land in that trimester;

$$(9)\ \begin{bmatrix} B_{4,7} \end{bmatrix} \cdot \begin{bmatrix} Z_{7,1} \end{bmatrix} \leq \begin{bmatrix} C_{4,1} \end{bmatrix}$$

which prevents monthly labor inputs of household females for the tobacco harvest from exceeding the monthly availability of such labor;

$$(10)\ \begin{bmatrix} B_{5,10}, & B_{5,11} \end{bmatrix} \cdot \begin{bmatrix} Z_{10,1} \\ Z_{11,1} \end{bmatrix} \leq \begin{bmatrix} C_{5,1} \end{bmatrix}$$

which prevents farm-grown sisal production from exceeding the amount presently grown;

$$(11)\ \begin{bmatrix} B_{6,9} & \cdots & B_{6,14} \end{bmatrix} \cdot \begin{bmatrix} Z_{9,1} \\ \vdots \\ Z_{14,1} \end{bmatrix} = \begin{bmatrix} C_{6,1} \end{bmatrix}$$

which prevents sisal and rope output from exceeding sisal input;

$$(12)\ \begin{bmatrix} B_{7,1}, & B_{7,4}, & B_{7,15} \end{bmatrix} \cdot \begin{bmatrix} Z_{1,1} \\ Z_{4,1} \\ Z_{15,1} \end{bmatrix} \geq \begin{bmatrix} C_{7,1} \end{bmatrix}$$

which sets minimum household nutrient requirements to be satisfied from purchased and farm-grown foods in Trimester I;

$$(13)\ \begin{bmatrix} B_{8,2}, & B_{8,5}, & B_{8,16} \end{bmatrix} \cdot \begin{bmatrix} Z_{2,1} \\ Z_{5,1} \\ Z_{16,1} \end{bmatrix} \geq \begin{bmatrix} C_{8,1} \end{bmatrix}$$

which sets minimum household nutrient requirements to be satisfied from purchased and farm-grown foods in Trimester II;

$$(14)\ \begin{bmatrix} B_{9,3}, & B_{9,6}, & B_{9,17} \end{bmatrix} \cdot \begin{bmatrix} Z_{3,1} \\ Z_{6,1} \\ Z_{17,1} \end{bmatrix} \geq \begin{bmatrix} C_{9,1} \end{bmatrix}$$

which sets minimum household nutrient requirements to be satisfied from purchased and farm-grown foods in Trimester III;

$$(15)\quad \begin{bmatrix} B_{7,1}, & B_{7,4}, & B_{7,15} \end{bmatrix} \cdot \begin{bmatrix} Z_{1,1} \\ Z_{4,1} \\ Z_{15,1} \end{bmatrix} = \begin{bmatrix} C_{10,1} \end{bmatrix}$$

which sets palatability standards for diets in Trimester I;

$$(16)\quad \begin{bmatrix} B_{8,2}, & B_{8,5}, & B_{8,16} \end{bmatrix} \cdot \begin{bmatrix} Z_{2,1} \\ Z_{5,1} \\ Z_{16,1} \end{bmatrix} = \begin{bmatrix} C_{11,1} \end{bmatrix}$$

which sets palatability standards for diets in Trimester II;

$$(17)\quad \begin{bmatrix} B_{9,3}, & B_{9,6}, & B_{9,17} \end{bmatrix} \cdot \begin{bmatrix} Z_{3,1} \\ Z_{6,1} \\ Z_{17,1} \end{bmatrix} = \begin{bmatrix} C_{12,1} \end{bmatrix}$$

which sets palatability standards for diets in Trimester III;

$$(18)\quad \begin{bmatrix} B_{13,15} & \cdot\cdot & B_{13,17} \end{bmatrix} \cdot \begin{bmatrix} Z_{15,1} \\ \vdots \\ Z_{17,1} \end{bmatrix} = \begin{bmatrix} C_{13,1} \end{bmatrix}$$

which forces home-grown non-*conuco* food crops and certain *conuco*-grown ones to enter the solution in fixed amounts, according to their production in the study year 1970-1971.

This basic model is adjusted slightly to conform to conditions particular to each of the five modal farms. Selected original data used in the farm models are contained in Appendices II through V.

CHAPTER VI

ANALYSIS OF RESULTS

Introduction

In this study, five peasant farms--differentiated primarily by quality of the physical resource base--were selected for modelling, and their resources and requirements applied in such a way as to yield land-use plans producing maximum net revenues. Three types of linear programming (LP) solution and analysis are applied to gain insight into the potentialities of each farm. These are: (a) the primal solution, which specifies the array of various activity levels necessary for revenue maximization; (b) the dual solution, which imputes values ("shadow prices") to resources and requirements within the framework of the primal solution; (c) parametric analysis, which determines the effect on a solution caused by the systematic increase or decrease in the value of one or more model parameter.

Because of the comprehensive nature of the models, which attempt to reflect some of the intricacies of the peasant farm, results are often complex and the mechanisms producing them obscure. While many alternate analytic approaches may be considered, interpretation in this study is confined to points bearing on the concept of the peasant farm as a manifestation of the interactions between cultural and biological man, on the one hand, and his physical surroundings, on the other.

In this chapter, the modal farms are first described briefly, after which the normative farm plans are presented and analyzed. For ease of interpretation, the model presented in Chapter V is developed in stages. Specifically, farm plans are presented which are derived from solution of three successive LP model types of increasing complexity: (a) a basic model, which contains neither risk-spreading considerations nor choice variables other than those currently practiced; (b) a risk-spreading model, which adds to the basic model a set of risk-spreading constraints; (c) an innovative model, which adds to the risk-spreading model the innovative cash-earning opportunities of sunflower growing and ropemaking. For convenience sake, the farm activity and food purchase schedules of the optimum solutions are discussed separately, although it should be emphasized that the two are integral parts of the same plans and cannot be applied independently of one another.

Description of Modal Farms

Farm I

The first of the five modal farms lies within the *seccion*'s highest rated multi-variate area of uniform agricultural productivity (MVAUAP 1-1-2).* It is 140 tareas in size, of which 50 tareas are in sisal, 10 tareas in guinea grass pasture, 70 tareas in brush, and 10 tareas in *conuco* crops. The *conuco* is located on level land,

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*Characterizations of the five modal farms describe conditions encountered during field observations during the period December, 1971-February, 1972. Production figures are from the previous year's two growing seasons that is, from September, 1970 to August, 1971.

and is in its first year of production.

The conuco is worked by the owner, aged sixty. Although he has four adult sons living with him, they work away from the farm sharecropping sisal. While the farmer recognizes that this is not the most profitable allocation of labor, his need for security and immediate cash is so pressing that he considers himself forced to follow this course of action. He is steadily converting his farm to sisal production, cleaning and working a conuco for one or two years, then planting it to sisal and guinea grass.

The farmer's cautiousness in farming strategy may be attributed in part to his responsibility as head of a household of ten members, five of whom are women or small children. Furthermore, he is old enough to remember the days before sisal introduction, when families were forced to leave their land in times of drought and migrate to the irrigated rice lands of the Yaque valley to seek out work as day laborers.

Conuco production for the 1970-1971 agricultural year is presented in Table VI. 1. Net household income was RD$440. 51 (see Table VI. 23).

Farm II

The second farm is a holding of 100 tareas, of which 65 tareas are in guinea grass pasture, 11 tareas in brush, and 24 tareas in first-year conuco production. On flat land in MVAUAP 1-2-2, the farm is a productive one.

TABLE VI.1 -- Crop Production, Destination and Revenue, Actual *Conuco* Situation, Farm I

Crop	Amount (hundredweight)	Destination	Net Revenue (pesos)
Tobacco	6.00	market	124.98
Yuca	11.00	household, livestock	
Sweet Potato	7.70	household, livestock	
Red Beans:			
First-Rains	.98	household	
Corn:			
First-Rains	1.92	household, livestock	
Pigeon Peas	1.20	household	
Papaya	.90	household	
Net Returns	-	--	RD$124.98

The parcel supports a household of six members, and is worked by the young farmer, his wife and a second woman. During the tobacco harvest, the farmer supplements his work-force with day laborers.

The farmer's strategy in planning his conuco layout is to produce only enough food crops for self-sufficiency in those foods--any surplus could only be given away--and to plant the remainder of the land to tobacco. He favors the latter as a cash crop, attributing his modest financial success to a series of good tobacco harvests. In contrast to the practice on the majority of farms in this region, tobacco here is first planted in seed-beds, then transplanted to the conuco. This added labor input increases yields.

The conuco is in its first year of production, and will be cultivated a second year before being planted to guinea grass. In addition to a cow of his own, the farmer pastures seven milk cows belonging to others, in exchange for half the milk production.

Sisal is not grown on the farm. Unlike most of the farmers interviewed, the farmer dislikes this crop, believing that it is unprofitable in the long run, since the land on which it is planted is more or less permanently removed from the cycle of shifting cultivation.

Table VI. 2 shows conuco production for the study period, while farm and household accounts are presented below in Table VI. 23.

Farm III

With a conuco located in a moist hollow (hoya) in MVAUAP 1-2-2, this farm is the most productive dry land farm encountered

TABLE VI.2 -- Crop Production, Destination and Revenue, Actual Conuco Situation, Farm II

Crop	Amount (hundredweight)	Destination	Net Revenue (pesos)
Tobacco	50.20	market	1140.54
Yuca	27.50	household, livestock	
Sweet Potato	8.80	household	
Broad Beans	.12	household	
Pigeon Peas	.24	household	
Papaya	.30	household	
Less hired labor for tobacco harvest			326.80
Net Returns	-	--	RD$ 813.74

in the study area.* The farm's 200 tareas are divided into lots of 20 tareas of conuco, 45 tareas of sisal land, 80 tareas in guinea grass pasture, and 55 tareas of brush. The study year 1970-1971 was the first of a four-year cycle of cultivation.

The conuco is worked by the farmer and his two young sons (ages 11 and 12). In order to supplement this labor force, the farmer hires peones during the tobacco harvest to pick and tie leaves.

A wide variety of crops is grown on the conuco (Table VI. 3). As with Farm II, an attempt is made to achieve self-sufficiency in food crops without producing a surplus. The remainder of the conuco is given over to tobacco, by far the most important crop, both in land use and labor utilization.

The farm supports ten people. In addition to revenues from tobacco, some cash is obtained from the growing of sisal, which is picked by sharecroppers in exchange for half of the harvest.

The farmer is very prosperous by local standards, to the extent that he owns a motorcycle (see Table VI. 23). Despite his success--a result of good crop-land and wise management--the farmer would like to sell his land and become a merchant, because he dislikes the hard work involved in agriculture.

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*A hoya farm in MVAUAP 1-1-2 would theoretically be the most productive farm in the sección. However, there are no hoya farms in this MVAUAP.

TABLE VI. 3 -- Crop Production, Destination and Revenue, Actual Conuco Situation, Farm III

Crop	Amount (hundredweight)	Destination	Net Revenue (pesos)
Tobacco	59. 50	market	1426. 81
Yuca	33. 00	household, livestock	
Sweet Potato	1. 65	household	
Red Beans:			
First Rains	. 12	household	
Second Rains	. 48	household	
Corn:			
Second Rains	2. 40	livestock, seed	
Onions	. 10	household	
Squash	. 36	household	
Watermelon	4. 00	household, livestock	
Plantains	2. 40	household	
Pigeon Peas	1. 20	household	
Papaya	2. 50	household	
Less hired labor for tobacco harvest			199. 92
Net Returns	-	--	RD$1226. 89

Farm IV

Located in a remote and rugged area, the few suitable conuco sites offered by MVAUAP 3a-1-2 are confined to hoya lands. The fourth farm, therefore, displays a degree of productivity per tarea second only to that of Farm III. By contrast with the other farmers surveyed, the operator of this parcel is a squatter (by permission of the absentee owner). With a total area of 200 tareas, the property has 30 tareas of conuco, 20 tareas of guinea grass pasture, and 150 tareas of thorn forest and brush. The conuco is in its first year of production, and will be worked for two more years.

The farm has no sisal because the owner will not permit it. Because he lacks this secure income source, the farmer has been obliged to migrate several times in periods of drought to find work as a peon in the Yaque valley.

The farmer supports his nine-member household by working the conuco with his two adult sons. Mutual work groups are used during the tobacco harvest. As on Farm II, this farmer transplants tobacco from seed-beds, thereby obtaining a yield higher than that of his less ambitious neighbors.

Many different food crops are grown for the family's consumption. Unwillingness to commit himself to the market any more than possible determines the farmer's planning approach with primary emphasis on food crop self-sufficiency, and cash crops being planted on the remaining land. Table VI. 4 presents data on conuco production. The productivity of the land manifests itself in the relatively high revenues of this farm (Table VI. 23).

Farm V

The fifth farm lies within the least promising MVAUAP of the sección. Of the farm's 214 tareas, 16 are in conuco crops, 14 in guinea grass, 20 in sisal, and 164 in brush. The poor quality of the land is reflected in low revenues (Table VI. 23).

The conuco site is level, and in its first year of cultivation during the study year. Following another year of cropping, the field will be planted to guinea grass.

The farm household includes the farmer, his wife and nine children, who range in ages from 3 to 18 years. Three people work the farm--the farmer and two teen-age sons. Work groups aid in the tobacco harvest.

A large selection of crops is grown, despite the generally poor yields (Table VI. 5). The family's need for cash is balanced against the desire for self-sufficiency in food crops. Supplemental purchases of yuca and sweet potato must be made during the year, evidencing a greater commitment on the part of the household to the market and to tobacco as a cash crop. In addition to conuco production, the farm possesses a number of goats (19), some of which are sold in the community. Expenditures approach income, resulting in a net

TABLE VI. 4 -- Crop Production, Destination and Revenue, Actual Conuco Situation, Farm IV

Crop	Amount (hundredweight)	Destination	Net Revenue (pesos)
Tobacco	69.60	market	1449.77
Yuca	27.50	household, livestock	
Sweet Potato	22.00	househood, livestock	
Red Beans:			
First Rains	.72	household	
Corn:			
First Rains	.60	livestock, seed	
Second Rains	1.80	livestock, seed	
Eggplant	.30	household	
Okra	.54	household	
Onions	.20	household	
Sesame	.10	household	
Squash	2.20	household	
Pigeon Peas	1.65	household	
Papaya	4.50	household	
Net Returns	-	--	RD$1449.77

TABLE VI. 5 -- Crop Production, Destination and Revenue, Actual Conuco Situation, Farm V

Crop	Amount) (hundredweight)	Destination	Net Revenue (pesos)
Tobacco	13.20	market	253.18
Yuca	1.65	household, livestock	
Sweet Potato	2.20	household, livestock	
Red Beans:			
First Rains	.36	household	
Corn:			
First Rains	3.60	household, livestock, seed	
Second Rains	1.20	livestock, seed	
Tomato	.30	household, gift	
Peppers	.15	household	
Eggplant	.24	household	
Okra	.50	household	
Squash	2.20	household, livestock, gift	
Watermelon	1.10	household, livestock	
Pigeon Peas	2.50	household	
Net Returns	-	--	RD$253.18

revenue precariously close to zero (see Table VI. 23).

Normative Farm Plans

Activities at Fixed Levels

Certain farm activities are entered into the model at fixed amounts, or are constrained by upper limits (Table VI. 6). These are currently practiced activities at levels which are retained in the optimum plans. The distinction is made between these and other choice variables for activities which either fall outside the scope of the plans (i. e., livestock and yard production), or which are *conuco* crops which cannot conveniently be considered competitive for space with other *conuco* crops (i. e., the cucurbits, papaya, pigeon peas, and broad beans).

An arbitrary upper take-home limit of one hundredweight per month per farm worker is placed on sharecropped sisal, on the assumption that the availability of this supplemental cash opportunity is restricted.

Farm Plans: Basic Models

The farm plans derived from the LP solution to the basic models are presented in Table VI. 7. The models exclude the risk-spreading constraints and sunflower growing and ropemaking as choice variables (constraint set [8] and choice variables $Z_{8,1}$ and $Z_{12,1}$, respectively, of Chapter V).

TABLE VI. 6 -- Activities Entering Plans at Fixed or Upper Limits

Activity	Limit[a]	Amount (hundredweight)				
		Farm I	II	III	IV	V
Sharecropped Sisal	up	12.00	24.00	36.00	36.00	36.00
Farm Sisal	up	16.50	-	22.00	-	13.20
Squash	up	.84	-	-	2.00	2.00
Watermelon	up	.50	-	-	-	1.00
Pigeon Peas	up	5.00	.24	6.00	1.50	2.50
Broad Beans	up	-	.12	-	-	-
Papaya	up	.90	.30	2.50	4.50	-
Plantain	up	-	17.50	2.40	-	-
Sweetsop	fx	-	-	-	.07	-
Soursop	fx	-	-	-	-	.50
Bitter Oranges	fx	-	-	-	-	.30
Sweet Oranges	fx	.15	-	.75	-	.50
Bitter Lemons	fx	-	3.00	-	-	-
Sweet Lemons	fx	-	-	.38	.60	-
Chicken	fx	.09	.42	.33	.22	.18
Eggs	fx	.26	.56	.26	.28	.08
Milk	fx	10.68	3.41	11.92	-	-
Pig	fx	.94	-	1.88	.94	-
Goat	fx	-	-	-	-	2.13

[a] "up" = upper limit, "fx" = fixed limit

TABLE VI.7 -- Optimum Conuco Crop Schedule, Production and Revenue: Basic Plans

Crop	Amount (hundredweight) Farm I	II	III	IV	V
Tobacco:					
Family Worked	8.34	13.01	35.74	63.53	22.86
Peon Harvested	6.50	13.04	75.22	26.08	-
Peon Transplanted and Harvested	-	44.54	-	-	-
Sweet Potato	7.00	-	-	31.31	-
Corn:					
First Rains	9.86	-	-	11.25	-
Second Rains	-	-	-	-	.41
Onions	-	-	.21	-	-
Peppers	-	-	-	-	8.12
Okra	-	-	-	10.81	1.89
Tomato	-	-	-	-	17.10
Squash	-	-	.65	2.18	-
Watermelon	-	-	.47	-	.87
Broad Beans	-	.12	-	-	-
Pigeon Peas	5.00	.24	6.00	1.50	2.00
Papaya	.90	.30	2.50	-	-
Net Revenue[a]	247.37	1472.29	2275.21	1666.54	461.11

[a] All revenues in pesos

Conuco crops

Relatively simple land use is specified under the basic plans. Tobacco is the dominant crop, both in labor and land use. * Within the systems described by the plans, tobacco is the major income generator, providing cash with which to purchase foods. Few food crops, other than those entered in fixed amounts, appear in the plans. It is evidently more profitable to grow tobacco for exchange, rather than to apply resources directly for food production. This economic phenomenon is dependent on the relative costs among food and tobacco crops, and market items. The result is a system which is at once more productive and more vulnerable than that of pure subsistence. While the opportunity to produce tobacco magnifies the ultimate nutrient yielding ability of the land, an added sensitivity to price fluctuation is incurred, as well as a heightened likelihood of total crop failure.

Under plans for all farms but Farm V, it is profitable to harvest tobacco by using family labor exclusively on part of the crop, and by hiring day-laborers for the remainder. On Farm II where the labor-demanding task of tobacco transplanting is practiced, the plan calls for auxilliary peones. Through the use of hired labor, family

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*In the sections which follow, what are described are normative conditions. When reference is made to current, or real, conditions, it is done so explicitly, or is evident by context.

labor availability does not absolutely limit the ability to produce tobacco. Once again, however, the cost of a higher level of production is an increased vulnerability to outside influences--labor shortages and rising wages, while the narrowed profit margins of peon-produced tobacco exacerbate the risks associated with commercial monoculture.

Land quality is important in the allocation of the tobacco harvest between family and outside labor sources. First, it acts to govern the relative profitability of tobacco versus other activities: in instances where the relative profits from family-produced tobacco are small, the smaller profits from peon-produced tobacco will preclude the latter from the plan. Secondly, as land quality determines the absolute amount of tobacco which can be produced on a conuco of given area, in general less outside labor will be required on conucos where the ratio of family labor supply to tobacco production is greater.

Labor productivity per man-hour is the other important variable affecting the choice whether to hire outside help for the tobacco harvest. In instances where land quality or labor productivity causes family labor to have a value to the system greater than RD$0.19 per man-hour (or RD$1.50 per day, the standard peon wage in 1971), it will increase net revenues to use day-laborers. As a rule, low family labor productivity will tend to create a labor shortage and increase the farm value of labor. Land quality, where high, will have the same effect by placing greater demands on the labor supply.

Food crop production is relatively low in all the basic farm plans. Generally speaking, these crops must compete among themselves for the land and labor resources not required by the tobacco crop. Of food crops scheduled to be grown in appreciable amounts, sweet potatoes and corn (first-rains crop) are important on Farms I and IV, okra on Farms IV and V, and peppers and tomatoes on Farm V. All these crops, with the exception of sweet potato, are planted and harvested prior to the tobacco season (see Figure IV. 2). The labor demands of tobacco seed bed preparation tend to preclude first-rains crops on Farm II, while the non-inclusion of such seemingly attractive crop activities as okra and first-rains corn in the Farm I model matrix partially accounts for the lack of activities in Trimester III (September-December). Interestingly enough, the currently ubiquitous yuca and red beans are not selected in any farm plan, leading to the conclusion that these two crops are not economical for the region of Entrada de Mao in terms of efficient resource use and household nutrient need.

Sisal

Competing for family labor are the various tasks connected with sisal production (Table VI. 8). Sharecropped sisal on a half-harvest basis enters all farm plans, the monthly amount being partially determined by the demands for tobacco labor. As a general rule, sisal amounts sharecropped approach the limit set in the model of one hundredweight per month per worker during the tobacco off-season. That land quality is a factor affecting the amount of sisal sharecropped

TABLE VI. 8 -- Optimum Sisal Harvesting Schedule and Amounts: Basic Plans

Activity	Amount (hundredweight) Farm I	II	III	IV	V
Farm-Grown Sisal:					
Sharecropped	14.16	-	13.25	-	-
Family-Harvested:					
Regime I[a]	1.61	-	3.83	-	5.65
Regime II[b]	.73	-	-	-	1.25
Regime III[c]	-	-	4.92	-	6.31
Sharecropped Sisal:					
January	-	-	-	3.00	2.14
February	-	1.10	-	2.56	2.30
March	-	.15	-	.34	1.16
April	-	-	.54	1.90	2.71
May	1.00	.53	1.79	1.88	3.00
June	.45	.61	.93	1.93	3.00
July	.05	1.63	3.00	3.00	3.00
August	.14	1.04	2.92	3.00	3.00
September	-	1.11	3.00	3.00	3.00
October	1.00	.23	2.43	3.00	3.00
November	1.00	1.85	3.00	3.00	3.00
December	1.00	1.92	2.15	--	3.00
Net Revenue[d]	150.06	101.73	351.39	266.06	455.07

[a] Sisal cutting in January, April, July and October

[b] Sisal cutting in February, May, August and November

[c] Sisal cutting in March, June, September and December

[d] All revenues in pesos

per family worker is suggested by the high amounts scheduled for Farm V (a yearly total of 10.77 cwt. per person, more than twice the amount specified for Farm I). This may be accounted for by the fact that poor land quality depresses on-farm returns to labor, and makes sisal sharecropping an attractive outlet for labor. In addition, and as mentioned previously, poor quality farm land creates what is, in effect, a labor surplus by providing a lower volume of crops to be worked.

The opportunity to sharecrop sisal results in a reduction in the variety of crops grown in the conuco, as the returns to labor of many crops make them non-competitive with this means of revenue-earning. Furthermore, money-generating activities would tend to supplant nutrient-generating ones because the latter have value only until family demand is met. The deterioration of local traditional agriculture following the introduction of an off-farm wage earning opportunity is a phenomenon which has been widely observed.

Complex and seemingly paradoxical systems of harvesting and processing farm-grown sisal are described in the plans. Because of variations in labor supply and demand--and thus of labor value--throughout the year, it is profitable in several instances to sharecrop off-farm sisal in certain months while having some farm sisal sharecropped by outsiders in other months. The remainder of the farm sisal is worked by the family.

Land and labor resources

Under the basic plans, neither land nor labor resources are used fully throughout the year. While at first glance it might seem surprising that plans describing the most efficient use of resources call for idle land and man-hours, in fact this is the normal situation where the exhaustion of the most limited resources precludes further use of the more abundant. In the basic LP model, there are in essence fifteen resources described--twelve of monthly labor availability, and three of trimestral land availability: it is inevitable that some resource units must go unused.

Table VI. 9 shows shadow prices of land and labor derived under the plans for the various farms. These shadow prices are the values placed on resources within a LP model, and do not necessarily bear a relationship to market prices. They are of analytical interest in that they are a measure of the value of each resource in its contribution to the net revenue objective. Value may be interpreted as the effect upon the objective function of an increase of the input of a resource by one unit. From the planner's standpoint, a resource having a high shadow price represents a point of sensitivity in an agricultural system, where an increase in the supply of that resource will have an amplified impact.

Resources having a shadow price of zero are those which are not used fully. A labor shadow price of RD$0. 09 per man-hour is an

TABLE VI.9 -- Resource Shadow Prices for Labor and Land: Basic Plans

Resource	Amount (pesos)				
	Farm I	II	III	IV	V
Labor:					
January	.09	.19	.19	-	.09
February	.27	.09	1.16	.09	.09
March	1.58	.09	.19	.09	.09
April	.18	.57	.09	.09	.09
May	-	.09	.09	.09	.09
June	.09	.09	.09	.09	.09
July	.09	.09	-	-	-
August	.09	.09	.09	-	-
September	.31	.09	-	.07	-
October	-	.09	.09	-	-
November	.01	.09	-	-	-
December	-	.09	.09	1.31	
Land:					
Trimester I[a]	.82	29.94	1.32	7.23	-
Trimester II[b]	12.99	-	88.14	14.58	7.34
Trimester III[c]	1.58	-	-	-	2.76

[a] January-April, [b] May-August, [c] September-December

indication that an additional man-hour could be used for sisal sharecropping, raising the value of the objective function by the above amount.* Peak values for labor occur during the tobacco season. In contrast to the actual labor demand situation, normative labor shadow prices do not fluctuate sharply during the year. Only in those months when labor supply limits tobacco production is there a large increase in value. The presence of the sisal sharecropping system helps to smooth over seasonal pulses in labor demand, and so serves a valuable purpose in alleviating seasonal unemployment. On the other hand, the extremely low monthly labor values attest to the low returns to labor prevalent in the region. A potentially unstable condition exists because the average peon wage of RD$0.19 per hour exceeds the shadow prices of labor in all but a few months of the year. On economic grounds, the opening up of outside labor opportunities in the region might be expected to cause the abandonment of traditional agricultural practices, or farming altogether on many of the poorer quality farms. As the isolation of Entrada de Mao is surmounted, important labor and land use changes are likely to occur.

As with labor, the value of land in the systems changes seasonally, having its peak value in one of the trimesters associated with the tobacco season. In the remaining trimesters, values are considerably lower, dropping to zero in some instances (an indication of idle land). On Farms IV and V, where there is a greater diversity in conuco crops, land value fluctuation is less than on those farms where there is little conuco activity outside of the tobacco season. In a general manner, peak land values reflect land value only in terms of tobacco-producing potential. The valuation of land by resource quality in relation to the principal crop lacks the additional dimension of economic rent. This would not be so if farm location affected the farm-gate price of tobacco, which it does not currently do. The introduction of a new cash crop, or the taking into account of transportation costs by discounting farm-gate prices, would cause profound changes in setting land values, and corresponding land-use changes could be expected to result.

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*Fifty-four man-hours per cwt. sisal, at RD$10.00 per cwt., sharecropped for half the amount, equals RD$0.09 per man-hour.

Farm Plans: Risk-Spreading Models

The farm plans produced by the basic models describe a market-oriented economy, essentially constituting a system in which tobacco is grown in exchange for cash, some of which, in turn, is traded for food for family maintenance; the remaining cash is reckoned (in this study) as net revenue. Labor not required for tobacco production is used to cut and process sisal, both that belonging to the farm, and that of other farms on a sharecrop basis for half the proceeds. A small food-growing subsystem co-exists, using resources not required in sisal and tobacco production.

The system described above does not currently function on the farms studied. In actuality, conucos support a greater variety of food crops and smaller amounts of tobacco. One important consideration supporting "semi-subsistence" agriculture is the unwillingness on the part of the farmer to commit all resources to one enterprise. Although net revenues are lowered, it is safer to limit the extent of any one activity.

The models now under discussion incorporate a method of risk-spreading observed in the study region: no more than a given fraction of the conuco area (in this study, one-half) is to be planted to any group of crops similarly susceptible to drought failure. With this new restriction, a number of changes in the basic plans take place.

Conuco crops

On all but one farm (Farm I), the variety of crops has increased (Table VI. 10). New crops entering the solutions are those which occupy land during the tobacco season. The limitation of land in tobacco permits the growing of these crops, which, under the basic plans, competed unsuccessfully with the cash crop. Second-rains corn is noteworthy among the food crops in that it enters the solutions in large amounts wherever it has been included as a choice variable. This is an indication of a favorable ratio of nutritional returns to resource input attributable to the crop. While some new crops have entered the plans, the amounts indicated for other crops

TABLE VI.10 -- Optimum Conuco Crop Schedule, Production and Revenue; Risk-Spreading Plans

Crop	Amount (hundredweight				
	Farm I	II	III	IV	V
Tobacco:					
Family Worked	7.33	1.66	39.18	51.72	11.43
Peon Harvested	5.83	24.39	16.38	-	-
Peon Transplanted and Harvested	-	9.24	-	-	-
Sweet Potato	11.34	27.72	15.60	82.22	-
Corn:					
First Rains	6.02	-	-	8.98	-
Second Rains	-	-	5.83	7.93	11.75
Red Beans:					
Second Rains	-	-	1.63	-	.40
Onions	-	-	14.06	.19	-
Peppers	-	-	-	-	8.51
Okra	-	-	-	-	.17
Tomato	-	-	-	-	17.10
Squash	-	-	.65	2.18	-
Watermelon	-	-	.47	-	.87
Broad Beans	-	.12	-	-	-
Pigeon Peas	5.00	.24	5.72	1.42	1.36
Papaya	.90	.30	2.50	4.50	-
Net Revenue[a]	218.69	775.35	1256.52	1077.32	238.09

[a] All revenues in pesos

in the basic plans have dropped in some instances. This is not a direct consequence of the risk-spreading consideration (except in the instance of Farm I, where the restriction limits the production of first-rains corn), but results from the reallocation of resources necessitated by the increase in crop variety.

Tobacco production on every farm is limited by risk-spreading. Of interest are the shifts in emphasis between family-worked and _peon_-worked tobacco. While it might seem likely that the hiring of outside labor would decline with the increased ability of the family to process the diminished volume of the crop, the situation is made complicated by variations in month-by-month resource availability, on the one hand, and in crop resource requirements, on the other. For example, illustrating the complexity, the release of land from tobacco production under risk-spreading on Farm I now permits the growing of sweet potatoes. Under the basic plan, the more profitable tobacco crop occupied land in Trimesters I and II, thus limiting the production of less profitable sweet potatoes which require land in Trimesters III and I. Under the risk-spreading plan, land which was previously idle and labor which was underutilized are now needed for sweet potato production, and it becomes more efficient to use family labor for the harvest of this crop, while hiring _peones_ for most of the tasks connected with tobacco.

Sisal

The sisal-cutting schedules are altered somewhat under the new plans, although the total amounts of sisal sold have changed little (Table VI.11). On Farms I, II, IV and V slightly more sisal is sharecropped, owing to the additional man-hours available from the reduction in tobacco production. On Farm III, the higher April and June labor demands (April onion planting and June corn harvest) have slightly reduced the sharecropping of sisal in those months. Furthermore, with the realignment of monthly labor requirements on Farm III made necessary by new crops (especially onions and corn), no farm sisal harvesting regime fits economically into the optimum schedule, and the most efficient use of scarce resources calls for the outside sharecropping of all farm-grown sisal.

Land and labor resources

Shadow prices of labor have declined slightly from their values in the basic plans (Table VI.12). This results from a lower labor demand and more months when labor is not used to the limits of its availability. Paradoxically, an increase in the variety of crops grown has also brought about a greater contrast in monthly labor demands. Evidently, the enforced idleness arising from the restriction of tobacco growing is not offset by the more complex cropping system which has taken tobacco's place.

The greatest effect on resource prices has been the decrease in land value. The limitation of farm area devoted to tobacco has reduced the imputed values within the systems of an additional tarea

TABLE VI. 11 -- Optimum Sisal Harvesting Schedule and Amounts: Risk-Spreading Plans

Activity	Amount (hundredweight) Farm I	II	III	IV	V
Farm-Grown Sisal:					
Sharecropped	14.65	-	22.00	--	-
Family Harvested,					
Regime I[a]	1.39	-	-	-	7.45
Regime II[b]	.46	-	-	-	-
Regime III[c]	-	-	-	-	5.75
Sharecropped Sisal:					
January	.99	-	-	3.00	2.42
February	-	.87	-	3.00	3.00
March	-	.45	-	.11	2.35
April	-	-	-	2.55	3.00
May	1.00	.11	1.12	1.31	2.56
June	.50	1.21	1.41	2.58	3.00
July	.08	1.63	3.00	3.00	3.00
August	.17	1.04	2.15	3.00	3.00
September	.32	1.11	3.00	3.00	3.00
October	1.00	.89	2.91	3.00	3.00
November	1.00	1.85	3.00	3.00	3.00
December	1.00	1.92	2.76	.66	3.00
Net Revenue[d]	152.29	110.80	318.70	282.05	475.22

[a] Sisal cut in January, April, July and October
[b] Sisal cut in February, May, August and November
[c] Sisal cut in March, June, September and December
[d] All revenues in pesos

TABLE VI.12 -- Resource Shadow Prices for Labor and Land: Risk-Spreading Plans

Resource	Amount (pesos)				
	Farm I	II	III	IV	V
Labor:					
January	.09	.19	.09	-	.09
February	.28	.09	.28	-	-
March	1.54	.09	.35	.09	.09
April	.19	.57	.19	.09	-
May	-	.09	.09	.09	.09
June	.09	.09	.09	.09	-
July	.09	.09	-	-	-
August	.09	.09	.09	-	-
September	.09	.09	-	-	-
October	-	.09	-	-	-
November	-	-	-	-	-
December	-	-	.09	.09	-
Land:					
Trimester I[a]	-	-	4.74	-	-
Trimester II[b]	13.15	-	-	1.92	-
Trimester III[c]	2.52	-	-	-	2.07

[a] January-April, [b] May-August, [c] September-December

of land. On Farm II, there is no trimester in which the conuco area is occupied to its limits. While this results in part from the few alternatives to tobacco on the farm which are more profitable than sharecropped sisal, it also illustrates the principle that land value is a reflection of the ability of the land to produce the principal cash crop. A reduction in ability--in this instance, a result of risk-spreading--brings about a reduction in land value.

Farm Plans: Innovative Models

An important, but often neglected, aspect of the introduction of new crops and enterprises to established farming communities is the investigation of the capacity of the existing system to admit new activities. Too often it is assumed that a profitable cash crop will create its own niche, while the potentially more unprofitable disruptive effects and repercussions in the system as a whole are overlooked. Innovation research should include the testing of the economic, as well as the technological and biological, viability of a new activity within an optimum system composed of currently existing elements. If the solution from a normative model includes the new activities at sufficient levels to justify the expenses of innovation, then--on economic-grounds--the innovation should benefit the agriculture of the region.

Two innovative sets of enterprises have been incorporated into the structure of the risk-spreading model. These are two sunflower crops--one for each rainy season--and twelve ropemaking activities--one for each month of the year. Both sunflower and ropemaking are considered promising innovations for this region of the Dominican Republic (DeCock, 1972).* It should be borne in mind that the viability of new activities depends to a large extent on their associated revenues. Any change in these revenues may change the status of the new activities in the optimum plans.

Conuco crops

Both sunflower crops enter optimum conuco plans for all farms but Farm I (Table VI.13). On this farm, conuco activities remain virtually unchanged. Apparently, sunflower cannot bring as much net revenue to the system as tobacco, sweet potatoes or corn. In contrast to the other farms, the high quality of the land in respect to corn makes this crop a more attractive one than sunflower. Given the absence of unused land on Farm I under the risk-spreading plan,

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*In the absence of detailed data, sunflower resource requirements are assumed to be equal for all the modal farms, and are those observed at the experiment station near Santiago. While in fact there will be some yield variations, sunflower's high degree of drought tolerance would tend to minimize these. A yield of 2 cwt. per tarea is a minimum expected yield. If sunflower is viable at this low yield, it will be successful at higher ones as well. The assumed price of RD$8.00 per cwt. f.o.b. is again a minimum one. Transport costs to La Vega (the site of the oil seed plant, located 84 kilometers by road from Entrada de Mao) are unknown, and are therefore not deducted from the price. A price of RD$16.00 per cwt. rope is that paid to ropemakers near Santiago, who, however, must import sisal from communities such as Entrada de Mao. While this figure applied to Entrada de Mao does not include transport costs, such costs may be compensated by cheaper sisal.

TABLE VI.13 -- Optimum *Conuco* Crop Schedule, Production and Revenue: Innovative Plans

	Amount (hundredweight)				
Crop	Farm I	II	III	IV	V
Tobacco:					
Family Worked	7.32	3.59	27.66	45.76	11.43
Peon Harvested	5.83	22.47	27.90	5.97	-
Peon Transplanted and Harvested	-	9.24	-	-	-
Sweet Potato	11.33	27.72	19.80	33.82	-
Corn:					
First Rains	7.41	-	-	1.05	-
Second Rains	-	-	-	-	.75
Beans:					
Second Rains	-	-	.34	-	-
Onions	-	-	.21	.19	-
Okra	-	-	-	6.23	-
Sesame	-	-	-	.22	-
Sunflower:					
First Rains	-	10.18	12.10	17.70	15.39
Second Rains	-	10.18	19.23	21.29	15.39
Squash	-	-	.65	2.17	-
Watermelon	-	-	.47	-	.87
Broad Beans	-	.12	-	-	-
Pigeon Peas	5.00	.24	4.62	1.42	2.50
Papaya	.90	.30	2.50	4.50	-
Net Revenue[a]	218.73	898.70	1443.69	1349.95	484.15

[a] All revenues in pesos

sunflower can only be introduced at the sacrifice of other crops. The imputed value of land (see Table VI.16) is higher on this farm than the others. The scarcity of land, coupled with the shortage of labor in April, July, and January (three of the four months required for the two sunflower crops), makes the application to sunflower production of these resources inefficient, in view of the returns. In order for a sunflower crop to enter the optimum plan for Farm I, revenue from the second-rains crop would have to be increased to RD$9.01, while that from the first-rains crop would have to climb to RD$18.57.

The combination of some unused land and labor on Farms II through V under the risk-spreading plans, together with lower yielding corn crops, makes sunflower an economic venture.

On no farm is there a change in the amount of tobacco scheduled for the innovative plans, although there are some shifts in the allocation of family as opposed to peon labor for this crop. Sweet potato production has suffered only on FarmIV; it has become profitable to divert some resources from this crop to allow for two sunflower crops, as well as for ones of sesame and okra. Corn has been virtually eliminated on all farms where it was previously scheduled.

It should be pointed out that sunflower-growing owes its place in the optimum farm plans to the risk-spreading restriction. If this restriction is relaxed, tobacco production increases at the expense of sunflower (Table VI.14), indicating the economic superiority of tobacco

TABLE VI. 14 -- Effect of Risk-Spreading on Cash Crop Production: Innovative Plans

Crop	Amount (hundredweight)				
	Farm I	II	III	IV	V
Innovative Plans					
Tobacco	13.15	35.30	55.56	51.73	11.43
Sunflower:					
First Rains	-	10.18	12.10	17.70	15.39
Second Rains	-	10.18	19.23	21.29	15.39
Innovative Plans Without Risk-Spreading					
Tobacco	14.11	66.73	110.96	89.71	22.86
Sunflower:					
First Rains	-	-	-	3.36	.46
Second Rains	-	-	-	3.33	.46

as an efficient revenue-earner. This suggests that institutional measures on the part of the government to assume the burden of risk-taking would be of greater economic benefit to local agriculture than the introduction of this new crop.

The varying reactions on the part of the various farms to the introduction of sunflower illustrates the danger of blanket recommendations for a region. Among many variables that must be considered is the one of spatial differences in land quality. Under conditions of uniform technology this manifests itself as differing sets of potential crop yields. Furthermore, the relationship between crop yields is not constant from one farm to another: that is to say, the yield of one crop may remain similar over a wide area, while that of another may be very sensitive to differences in land quality. Economical crop innovation on a parcel of land is not just a question of absolute yield, but of the crop's yield in relation to a set of potential yields for a range of crops.

Sisal and ropemaking

The sharecropping of sisal remains an important enterprise despite the new alternatives (Table VI.15). On Farms II, III, and V the amounts of sharecropped fiber have dropped somewhat, while on Farm IV they have risen slightly. These changes are a result of the realignment of labor demands caused by the planting of sunflower and the rearrangement of conuco crops, rather than by direct competition

TABLE VI.15 -- Optimum Sisal Harvesting and Ropemaking Schedules: Innovative Plans

Activity	Amount (hundredweight)				
	Farm I	II	III	IV	V
Farm-Grown Sisal:					
Sharecropped	14.65	-	10.78	-	-
Family Harvested,					
Regime I[a]	1.39	-	11.22	-	7.45
Regime II[b]	.46	-	-	-	5.75
Regime III[c]	-	-	-	-	-
Sharecropped Sisal:					
January	.99	-	.13	3.00	2.40
February	-	1.07	-	3.00	3.00
March	-	-	-	-	1.43
April	-	.39	-	2.89	3.00
May	1.00	.16	.78	1.37	2.57
June	.50	1.61	1.87	2.91	3.00
July	.08	1.62	2.66	3.00	3.00
August	.17	-	.96	1.99	3.00
September	.32	1.11	3.00	3.00	3.00
October	1.00	.18	.68	3.00	3.00
November	1.00	1.85	3.00	3.00	3.00
December	1.00	1.92	2.77	1.31	3.00
Ropemaking:					
January	-	-	-	.33	-
February	-	-	-	.09	.02
March	-	-	-	-	-
April	-	-	-	-	-
May	.06	-	-	-	-
June	-	-	-	-	.16
July	-	-	-	.81	.28
August	-	-	-	-	.05
September	-	-	.45	.40	.56
October	.17	-	-	-	.21
November	.06	-	.09	.64	.65
December	.25	-	-	-	.56
Net Revenue[d]	155.55	99.18	327.97	283.00	480.97

[a] Sisal cut in January, April, July and October

[b] Sisal cut in February, May, August and November

[c] Sisal cut in March, June, September and December

[d] All revenues in pesos

for labor between sisal and sunflower.

Ropemaking does not appear to be as promising an innovation as sunflower. With a labor return of RD$0.02 per man-hour--less than the returns from sisal sharecropping--it offers an unsatisfactory means of absorbing excess labor. In the optimizing plans, ropemaking enters as an activity only in months when the imposed limit of one hundredweight of sharecropped sisal per month per person has been reached. Ropemaking is only selected when all other means of utilizing labor have been exhausted.

Land and labor resources

The innovative activities, by introducing additional revenues, enhance imputed resource values (Table VI.16). Labor shadow prices show the effect of ropemaking in months where previously there were labor surpluses. Months in which labor shadow prices exceed RD$0.09 (the man-hour return from sharecropped sisal) indicate times when labor supply limits conuco production. Labor supply limits cropping in some months of the year on all farms but Farm V, where a combination of poor land quality and a high man-land ratio creates a surplus labor condition. The critical month for labor supply is March, when three tobacco pickings place a premium on additional man-hours. Land values, too, are higher in the innovating plans, testifying to the greater financial rewards per tarea made possible by the planting of sunflower.

TABLE VI. 16 -- Resource Shadow Prices: Labor and Land: Innovative Plans

Resource	Amount (pesos)				
	Farm I	II	III	IV	V
Labor:					
January	.09	.19	.09	.02	.09
February	.25	.09	.24	.02	.02
March	1.56	.49	.40	.57	.09
April	.17	.09	.09	.09	.02
May	.02	.09	.09	.09	.09
June	.09	.09	.09	.09	.02
July	.09	.09	.09	.02	.02
August	.09	.64	.09	.09	.02
September	.09	.09	.02	.02	.02
October	.02	.09	.09	.04	.02
November	.02	.09	.02	.02	.02
December	.02	.09	.09	.09	.02
Land:					
Trimester I[a]	.12	5.59	4.04	-	3.80
Trimester II[b]	13.13	.54	10.24	9.50	3.54
Trimester III[c]	2.44	-	2.16	2.85	9.94

Optimum Diet Plans

Less obvious than land-use as a facet of man's relationship with his environment is the equally important one of diet. The need for food--whether it be home-grown or purchased--is the link which ultimately binds man inescapably to the soil. In the models, food items, as nutrient "packages," are evaluated by cost--either market price or farm resource cost--and by the nutrient needs of the household.

Diet composition under the risk-spreading plans* is similar among the farms, although amounts naturally differ with the magnitude of nutrient need (Tables VI.17 and VI.18). Similarities in composition result from the fact that each nutrient is most cheaply supplied by a particular food. Complicating this feature are the necessary concessions to palatability which may force relatively uneconomical foods into the diets. Palatability, in fact, forms the underlying dietary structure in the models; few foods are found in the plans which do not owe their presence to this consideration.

While a palatable diet may satisfy nutrient requirements, it does so at a cost which may be considerably in excess of that of a simple least-cost collection of foods which meet nutrient needs.

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*For the sake of brevity, only diets specified by the risk-spreading plans will be discussed in any detail. Diets generated by the other models show little difference in food composition, the major changes involving the origins of foods, whether conuco-grown or purchased.

TABLE VI. 17 -- Optimum Diets under Risk-Spreading Plans: Food Purchase Schedule and Amounts

Food Item	Amount (hundredweight)				
	Farm I	II	III	IV	V
Trimester I					
Rice	3.67	2.38	3.97	3.56	4.36
Sweet Potato	.20	-	-	-	11.35
Garlic	.15	.03	.17	.04	.05
Onions	.65	.12	.74	-	.23
Salt Cod	.04	-	-	-	-
Milk	6.14	4.04	6.52	3.88	10.55
Lard	1.04	.40	.80	.60	.73
Sugar	2.76	.72	1.23	1.13	1.33
Coffee	.54	.14	.24	.22	.26
Sesame	.21	-	.21	-	.23
Oil	-	-	.36	-	-
Red Beans	-	.71	-	-	-
Trimester II					
Rice	3.91	2.44	4.07	3.65	4.47
Sweet Potato	8.24	.63	10.58	-	11.64
Garlic	.07	.03	.05	.04	.05
Onions	.29	.13	.21	.19	.23
Red Beans	2.26	.98	-	1.46	1.79
Salt Cod	1.42	.36	.66	-	-
Milk	5.35	2.59	6.35	10.28	11.47
Lard	.74	.40	-	.61	.75
Sugar	1.66	.77	1.29	1.13	1.39
Coffee	.32	.15	.25	.22	.27
Sesame	.21	.13	.21	-	.23
Oil	.21	-	.68	-	-
Trimester III					
Rice	3.85	2.42	4.04	3.62	4.43
Sweet Potato	10.05	6.30	10.49	9.44	11.54
Garlic	.05	.03	.05	.04	.05
Onions	.20	.13	-	.19	.23
Broad Beans	2.75	3.64	1.07	-	-
Pigeon Peas	1.54	.97	1.62	1.45	1.77

TABLE VI. 17 -- (Continued)

Food Item	Amount (hundredweight)				
	Farm I	II	III	IV	V
Salt Cod	-	-	-	.03	-
Sardines	-	-	-	.10	-
Milk	7.48	2.08	5.01	7.33	9.44
Lard	.65	.40	.68	.61	.74
Sugar	1.18	.77	1.23	1.13	1.39
Coffee	.23	.15	.24	.22	.27
Sesame	.21	.13	.21	.18	.23
Oranges	10.00	6.00	10.00	9.00	11.00
Annual Expenditures[a]	754.37	397.68	683.50	527.70	829.59

[a]Expenditures in pesos, [b]Weight as purchased

TABLE VI.18 -- Optimum Diets under Risk-Spreading Plans: Farm-Grown Food Schedule and Amounts

	Amount (hundredweight)				
Food Item	Farm I	II	III	IV	V
Trimester I					
Sweet Potato	9.37	22.00	15.60	70.27	-
Pigeon Peas	5.00	.24	5.73	1.42	1.36
Red Beans	-	-	-	-	.40
Peppers	-	-	-	-	8.51
Watermelon	-	-	-	-	.87
Squash	-	-	-	1.80	-
Onions	-	-	-	.19	-
Okra	-	-	-	-	.17
Soursop	-	-	-	-	.50
Sweetsop	-	-	-	.06	-
Milk	2.67	.85	2.98	-	-
Chicken	.03	.14	.11	-	.06
Eggs	.13	.28	.13	.28	.04
Goat	-	-	-	-	.71
Trimester II					
Sweet Potato	1.97	5.72	-	11.95	-
Corn	-	-	5.83	7.93	11.75
Red Beans	-	-	1.63	-	-
Watermelon	-	-	.47	-	--
Squash	-	-	.65	.38	-
Broad Beans	-	.12	-	-	-
Papaya	-	.30	-	-	-
Plantains	-	17.50	-	-	-
Milk	5.34	1.71	5.96	-	-
Chicken	.03	.14	.11	.08	.06
Pig	-	-	-	.94	-
Goat	-	-	-	-	.71
Trimester III					
Corn	6.41	-	-	8.98	-
Onions	-	-	14.06	-	-
Tomatoes	-	-	-	-	17.10
Papaya	.90	-	2.50	4.50	-
Sweet Lemons	-	-	.38	.60	-
Bitter Lemons	-	-	3.00	-	-

TABLE VI.18 -- (Continued)

Food Item	Amount (hundredweight)				
	Farm I	II	III	IV	V
Sweet Oranges	.15	-	.75	-	-
Bitter Oranges	-	-	-	-	.30
Sweetsop	-	-	-	.07	-
Milk	2.67	.85	2.98	-	-
Chicken	.03	.14	.11	.07	.06
Eggs	.13	.28	.13	-	.04
Pig	.94	-	1.88	-	--
Goat	-	-	-	-	.71

Marginal values* of palatability requirements attest to this fact (Table VI. 19). The cost of food preference is high and varies both spatially and seasonally, owing to differences in land quality and seasonal changes in the availability of food items.

The diets scheduled in the risk-spreading plans fulfill most nutritional requirements easily. A comparison of Tables VI. 20 and VI. 21 shows the contrast between annual nutrient intakes under the proposed diets and estimates of actual intakes. It is clear that actual diets are substandard in nearly all nutrients, especially calcium, retinol, riboflavin, and niacin. It is difficult to judge the adequacy of protein intake, as no qualitative distinction has been made as to protein completeness. Disparities among farms in actual nutrient intake may be accounted for by differences in food crop output, wealth, ratio of household size to conuco size, and family dietary wisdom.

Household nutrient intake differences are largely eliminated under the optimum plans. Nutrients furnished at lowest acceptable amounts (i.e., at 100 percent of Recommended Dietary Allowance [RDA]) are those which restrain net revenue maximization; in supplying scarce nutrients, the models provide remaining nutrients in excess quantities. Scarce nutrients are not necessarily those which are

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*In a LP problem whose objective is to minimize the total cost of food for given levels of nutrient and palatability outputs, the shadow prices of the outputs are equivalent to their marginal costs.

TABLE VI.19 -- Marginal Costs of Palatability Requirements: Risk-Spreading Plans

Requirement No.[a]	Cost (pesos/cwt.)				
	Farm I	II	III	IV	V
Trimester I					
1	3.97	-	-	-	6.06
2	10.30	22.27	14.57	20.43	14.46
3	39.50	39.50	57.82	39.50	39.50
4	-	14.27	-	6.73	-
5	56.51	58.15	57.22	60.00	56.49
6	6.04	7.30	6.37	.65	6.60
7	2.69	-	-	-	-
8	-	-	-	-	-
9	-	74.52	22.06	81.12	62.82
10	7.89	8.00	7.86	8.00	7.89
11	12.19	-	13.11	-	-
12	-	-	-	-	-
13	-	-	18.32	-	-
Trimester II					
1	.29	2.49	2.17	-	4.39
2	7.94	15.60	14.47	19.55	23.83
3	37.65	39.50	57.82	39.50	39.50
4	-	11.77	4.81	15.63	19.53
5	51.82	56.04	56.17	57.18	58.10
6	10.14	11.07	10.82	11.30	11.74
7	-	-	-	-	-
8	-	-	-	-	-
9	2.42	12.83	1.82	33.07	61.93
10	7.07	7.93	7.84	7.84	7.83
11	34.17	-	19.68	19.99	-
12	-	-	-	-	-
13	-	-	18.32	-	-
Trimester III					
1	-	2.42	2.42	3.79	4.14
2	15.15	15.15	14.32	20.75	22.22
3	39.50	39.50	39.50	39.50	39.50
4	8.94	8.94	6.87	14.19	15.57
5	66.36	66.36	66.36	67.55	67.87
6	15.89	15.89	-	16.45	16.60
7	-	-	-	31.90	-
8	-	-	-	-	-

TABLE VI. 19 -- (Continued)

Requirement No.[a]	Cost (pesos/cwt.) Farm I	II	III	IV	V
9	16.31	16.31	53.42	16.31	63.14
10	7.83	7.83	7.83	7.83	7.82
11	21.20	21.20	22.76	21.20	-
12	.48	.48	.19	.48	-
13	-	-	-	-	-

[a] Explanation of requirement numbers:
1 - Minimum amount of yuca or sweet potato;
2 - Minimum amount of rice;
3 - Minimum amount of lard or oil;
4 - Minimum proportion of beans to rice;
5 - Minimum proportion of garlic to beans;
6 - Minimum proportion of onions to beans;
7 - Minimum amount of meat or fish;
8 - Minimum amount of milk;
9 - Minimum amount of coffee
10 - Minimum proportion of sugar to coffee
11 - Maximum amount of sesame;
12 - Maximum amount of oranges;
13 - Maximum amount of lard.

TABLE VI. 20 -- Percentage of Recommended Dietary Allowances of Nutrients Supplied by Optimum Diets: Risk-Spreading Plans

Nutrient	Percent of RDA				
	Farm I	II	III	IV	V
Calories	115	146	138	174	124
Protein	186	195	222	166	188
Calcium	100	102	100	105	100
Phosphorus	160	156	130	162	127
Iron	121	164	130	171	142
Vit. A (Retinol)	128	294	157	406	184
Thiamine	157	199	214	270	189
Riboflavin	115	105	136	118	140
Niacin	100	100	100	126	100
Ascorbic Acid	281	790	568	927	739
Carbohydrate	426	528	412	616	392

TABLE VI. 21 -- Percentage of Recommended Dietary Allowances of Nutrients Supplied by Current Estimated Farm Diets and the National Diet

	Percent of RDA					
	Farm I[a]	II	III	IV	V	Nat'l Diet[b]
Calories	67	120	147	84	61	76
Protein	91	122	175	106	93	81
Calcium	22	40	49	23	26	62
Phosphorus	71	85	89	74	51	112
Iron	82	93	108	93	64	76
Vit. A. (Retinol)	38	61	41	41	52	47
Thiamine	69	90	127	89	64	96
Riboflavin	27	43	78	31	36	55
Niacin	57	70	87	64	37	67
Ascorbic Acid	131	229	312	140	165	75
Carbohydrate	312	385	477	330	204	n.a.

[a] National diet figures from Sebrell, King, Webb et al. (1972)

[b] National RDAs based on Recommendations of INCAP (Sebrell, King, Webb et al., 1972) adjusted for age and sex distribution

seriously undersupplied in actual diets. In general, supplies of calcium and niacin are most critical to the farm plans, although seasonal changes in food availability may make other nutrients temporarily scarce. Table VI. 22 shows nutrient shadow prices for the farm households by trimester. The relatively high marginal costs per scarce nutrient unit suggest that a promising avenue of investigation for development planners for this region would be that of determining the feasibility of supplying free or low-cost supplements of calcium and B-complex. It is clear that a national program of food fortification, as recommended in the Dominican national nutritional survey (Sebrell, King, Webb *et al.*, 1972, p. 13), could have a significant impact on the normative revenue-producing potential of peasant farms.

Farm Revenues: A Summary

Table VI. 23 is a summary of the income and expenditures for the modal farms under the plans generated by the three model types, and allows a comparison with current revenues.

Unencumbered by precautions against uncertainty, the basic model displays the highest net revenues of the three models. In the appropriate season, all resources are deployed in the production of tobacco. Remaining resources are used for harvesting and processing sisal and for the cultivation of food crops. The portion of the budget allocated to food purchases is relatively high because of lower amounts

TABLE VI. 22 -- Marginal Costs of Nutrients, Risk-Spreading Plans

Nutrient	Cost (pesos)[a] Farm I	II	III	IV	V
Trimester I					
Calories	-	-	-	-	-
Protein	-	-	-	-	-
Calcium	.06	-	.06	-	.04
Phosphorus	-	-	-	-	.04
Iron	-	-	-	-	-
Vit. A (Retinol)	-	-	-	-	-
Thiamine	-	-	-	-	-
Riboflavin	-	49.00	-	-	-
Niacin	10.00	1.00	7.00	-	2.00
Ascorbic Acid	-	-	-	-	-
Carbohydrate	-	-	-	-	-
Trimester II					
Calories	.01	-	-	-	-
Protein	-	-	-	-	-
Calcium	.06	.03	.07	.07	.08
Phosphorus	-	-	-	-	-
Iron	-	-	-	-	-
Vit. A (Retinol)	-	-	-	-	-
Thiamine	50.00	-	-	-	-
Riboflavin	-	31.00	-	-	-
Niacin	10.00	9.00	11.00	6.00	3.00
Ascorbic Acid	-	-	-	-	-
Carbohydrate	-	-	-	-	-
Trimester III					
Calories	-	-	-	-	-
Protein	-	-	-	-	-
Calcium	.08	.08	.08	.08	.08
Phosphorus	-	-	-	-	-
Iron	-	-	-	-	-
Vit. A (Retinol)	-	-	-	-	-
Thiamine	-	-	-	-	-
Riboflavin	-	-	-	-	-
Niacin	10.00	10.00	10.00	5.00	3.00
Ascorbic Acid	-	-	-	-	-
Carbohydrate	-	-	-	-	-

[a] Costs are expressed in terms of pesos/gram for all nutrients except for calories, which are expressed in terms of pesos/1000 Calories.

TABLE VI.23 -- Summary of Revenues under Current Practices and Optimum Plans

Item	Amount (pesos)				
	Farm I	II	III	IV	V
Current Revenue					
Tobacco sale	124.98	813.74	1226.89	1449.77	253.18
Sisal sale	180.00	-	100.00	-	132.00
Food purchases	-508.17	-575.46	- 366.51	- 523.44	- 443.34
Miscellaneous[a]	643.70	45.00	- 61.50	141.60	93.00
Net Revenue	440.51	283.28	898.88	1067.93	39.84
Basic Plan					
Tobacco sale	247.37	1472.29	2275.21	166.54	461.11
Sisal sale	150.06	101.73	351.39	266.06	455.07
Food purchases	-773.01	- 570.75	- 818.85	- 620.28	- 898.49
Miscellaneous[b]	637.64	- 63.00	- 79.22	- 2.58	83.03
Net Revenue	262.06	940.27	1728.53	1309.74	100.72
Risk-Spreading Plan					
Tobacco sale	218.69	775.35	1256.52	1077.32	238.09
Sisal sale	152.29	110.80	318.70	282.05	475.22
Food purchases	-754.37	- 397.68	- 683.50	- 527.70	- 829.59
Miscellaneous[b]	637.64	- 63.00	- 79.22	- 2.58	- 83.03
Net Revenue	254.25	425.47	830.22	829.09	- 33.25
Innovative Plan					
Tobacco sale	218.73	735.82	1193.05	1077.33	238.07
Sunflower sale	-	162.88	250.64	272.62	246.08
Sisal sale	146.91	99.18	319.20	248.12	441.23
Rope sale	8.64	-	8.77	34.88	39.74
Food purchases	-754.43	- 420.99	- 758.20	- 632.20	-1003.01
Miscellaneous[b]	637.64	- 63.00	- 79.22	- 2.58	83.03
Net Revenue	257.49	513.89	934.24	998.17	45.14

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[a] These are revenues from sources not considered in the models. They are, for Farm I: plowing (-10.00), off-farm work (30.00), pig (5.00), calf (80.00), sisal sharecropped by sons (538.70); for Farm II: plowing (-24.00), off-farm work (35.00), guinea grass (60.00), chicken feed (-26.00), pig feed (-9.00); for Farm III: plowing (-20.00), charcoal (10.00), outside labor (-30.00), chicken feed (-39.22), pig feed (-14.50); for Farm IV: plowing (-30.00), charcoal (150.00), pigs (21.00), eggs (0.60); for Farm V: plowing

TABLE VI. 23 -- (Continued)

(-16.00), palm fronds (20.00), charcoal (100.00), chicken feed (-6.00).

[b] Same as above with the addition of expenditures for animal feed to compensate the loss of the conuco as a feed source in the plans; for Farm I: -6.06; for Farm II: -99.00; for Farm III: -24.72; for Farm IV: -144.18; for Farm V: -14.97.

of conuco-grown provisions.

The effect of risk-spreading on farm plans is to reduce specialization, commercialization, and net revenues. Although outside food purchases decline with the increase in home production, the reduction in expenditures does not offset the losses from diminished tobacco production. The revenue-depressing effects of risk-spreading differ from farm to farm.

Net revenues increase with the innovative cash-earning opportunities of sunflower and ropemaking. Most additional income comes from the sale of sunflower seed, while ropemaking contributes little. Because sunflower growing uses both resources which were idle and those which were used for food growing under the risk-spreading plans, there is an increase in food expenditures. Sisal production is barely affected by the innovations.

A comparison of the potential net revenue-earning abilities of each farm with its current situation offers varying degrees of encouragement. While great increases are possible on a farm such as Farm II, solutions for Farm I show an income decline. Actual incomes on all farms are deceptively high and would be considerably less if current diets were adequate. On farms where actual nutrient intakes are significantly substandard, a least-cost diet which is nutritionally adequate may cost more than the current one.

At the level of the individual farm, it is encouraging that it is possible to specify feasible farming systems which will allow a peasant and his family to earn a physiologically adequate living, while not necessarily a financially rewarding one. However, at the regional or national scale, it must be questioned whether or not it is wasteful, even under optimum schedules, to employ labor and land in such a way that these resources have such little value. Ultimately, in modern society, stable agricultural systems must impute values to resources which are comparable to their market values.

Optimum Man-Land Ratios

The central question to be asked when examining man-land relationships concerns the carrying capacity of the land: what is the optimum man-land ratio? Because agricultural potential is affected both by the spatial distribution of resources and by the nature of the local man-land association, it follows that optimum carrying capacities are similarly affected. Outside observers should not lose sight of the spatially and culturally variable nature of carrying capacities, and should hesitate before declaring a region "overpopulated." Such caution can be shown to be justified in analyzing the optimum size of man-land ratios on the farms dealt within this study.

Family labor on the modal farms is a limiting factor in at least several months of the year under all optimum plans, while there is considerable underemployment of family labor in other months. Sharp seasonal contrasts in labor demand account for this situation.

Because the family work force is of fixed size and must be maintained in both on- and off-seasons, the conclusion might be readily and erroneously drawn that a situation of overpopulation exists. However, it is peak seasonal labor demand--not total annual labor demand--in relation to the size of the family work force which must be taken into account in estimating the most productive ratios of labor to land.

The equilibrium point at which the output of an extra laborer equals the cost of the labor is the point at which man-land ratios yield the highest net revenues. In the peasant family-worked farm situation, the calculation of the cost of a family laborer must include the cost of total annual support, while the determination of labor productivity involves the value of the total annual contribution of the laborer.

Using the technique of parametric analysis, extra hypothetical family laborers were systematically added to the labor forces of each farm, and the effects upon net-revenues under the risk-spreading plan were plotted. The results are presented in Figure VI. 1. It is noteworthy that on Farms I-IV extra family laborers would add to net output. Only Farm V, located on the poorest land, would benefit from fewer family workers.

Of particular interest are the assymetrical slopes of the revenue curves for Farms I, II and V. They are steep in their approach to the point of optimality, indicating that the value of the additional labor output far exceeds the additional cost of labor. In contrast, the more gradual descent of the curve after equilibrium demonstrates that, while

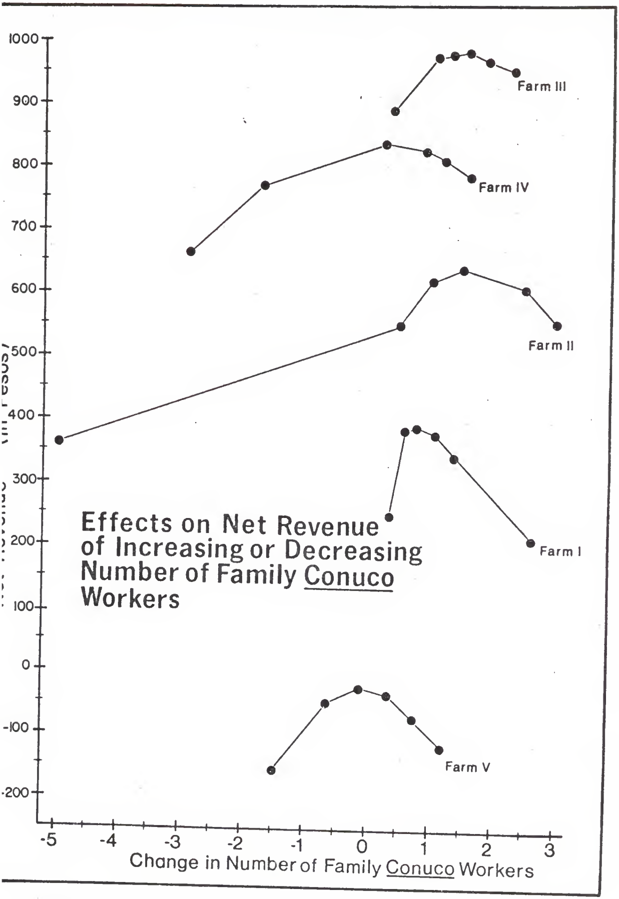
Effects on Net Revenue of Increasing or Decreasing Number of Family Conuco Workers
1000
900
800
700
600
500
400
300
200
100
0
-100
-200
Farm III
Farm IV
Farm II
Farm I
Farm V
-5
-4
-3
-2
-1
0
1
2
3
Change in Number of Family Conuco Workers

Figure VI. 1

the additional cost of labor now exceeds the additional value of labor output, the difference between cost and output is less than that between output and cost on the ascending curve. A peasant farmer must set a minimum size to his family labor force through family planning, fathering enough healthy sons over enough years to ensure an adequate labor supply throughout his productive lifetime and to provide for him when he has become too old to farm. The difference between marginal net product before net revenue maximization and marginal net cost afterwards suggests that an error on the part of the farmer on the side of overpopulation detracts less from net revenues than one whereby the farm is undermanned. If a similar assymetry of the revenue curve exists under current practices, it may well provide a logical rationale for apparent overpopulation.

As a rule, it may be said that the greater the potential productivity of the land, the higher the optimum man-land ratio. This applies to potential productivity in the sense of land quality, as well as potential allowed by the range of opportunities. Thus, optimum ratios are higher under plans generated by the basic and innovative models, than by the risk-spreading one (Table VI.24).

TABLE VI. 24 -- Current and Optimum Man-Land Ratios[a] and Associated Net Revenues

Item	Amount				
	Farm I	II	III	IV	V
Current Practice					
Ratio	.10	.13	.15	.10	.19
Net Revenue[b]	440.51	283.28	898.88	1067.93	39.84
Basic Plan					
Optimum ratio	.19	.21	.29	.16	.19
Net Revenue[b]	538.83	1195.10	1967.00	1524.14	126.73
Risk-Spreading Plan					
Optimum ratio	.18	.19	.23	.11	.18
Net Revenue[b]	382.32	630.38	973.13	834.07	-30.81
Innovative Plan					
Optimum ratio	.19	.21	.24	.12	.18
Net Revenue[b]	404.89	802.81	1141.16	1042.75	46.80

[a] Family farm workers per tarea of conuco land
[b] In pesos

CHAPTER VII

SUMMARY AND CONCLUSION

Summary

Problem and Objectives

A universal goal of agricultural planners is to increase farm productivity. Growing attention is being paid to the problems of generally low agricultural productivity throughout the Third World, especially among the peasantry. Most commonly, development efforts are concentrated upon technical or economic improvements in farming methods or materials. One promising approach is the raising of production levels through the more efficient allocation of presently available farm resources. Unfortunately, many resource allocation strategies are designed with built-in assumptions peculiar to commercial agriculture, and show little appreciation of the realities of Third World peasant agriculture. Little work has been done to provide suitable development models specifically appropriate to the peasantry, the largest and neediest agricultural group in the world.

The objective of this study was to construct and apply normative land-use models expressly intended for peasant agriculture--models which recognize the special problems and goals of the peasantry. The geographic concept of the farm as a local expression of the interaction between the two spatial variables of agricultural resources and the man-land association has governed the approach to this objective. The physical and cultural restrictions imposed on present farm resource use, determining current levels of production, must be considered in designing plans for more efficient resource allocation.

Analysis of the relationship between the peasant and the land reveals its unique economic nature. Unlike the situation on capitalist commercial farms, labor on peasant farms represents a fixed cost, rather than a variable one. Family labor cannot be laid off and on in accordance with profit maximization; it must be supported regardless of man-hours worked. The peasant farm is therefore inextricably composed of the two components of land and household; each depends on the other--the land on the household for labor, the household on the land for sustenance. With this view of the peasant family farm as an organic unit, the twin problems of improvement of farm production and enhancement of household welfare become aspects of the one problem of efficient allocation of farm resources.

Method

A theoretical farm-level linear programming (LP) model was designed, whose objective function was the maximization of peasant farm net revenue (income less expenditures) through the most efficient use of limited farm resources. Also constraining the objective function was a provision for a nutritionally adequate diet, to be provided either from farm-grown foods or from market purchases. A further model consideration was the inclusion of a risk-spreading system as a technique against rainfall uncertainty.

The theoretical model was applied to particular farm situations in Entrada de Mao, a peasant community in the semi-arid northwestern Dominican Republic. The model was adjusted to conform to local conditions. Field work was carried out from December, 1971 through February, 1972.

For analytic purposes, the farm models were developed in three phases. The first-phase, or basic, model-type was a simple net-revenue maximizing one, constrained by seasonal availability of land and labor, nutrient requirements, and palatability considerations. The second phase introduced constraints of risk-spreading to the basic model-type. In the final phase, the innovative activities of sunflower growing and ropemaking were added to the array of choice variables in order to examine their roles in optimum farm systems.

Results

Results show that net revenues on the modal farms could be increased substantially by a reallocation of resources as specified in plans developed under the basic models. A greater farm resource commitment to tobacco growing and a correspondingly greater reliance on the market as a food source would set net revenues at a maximum. With the addition of the strategy of spreading risks over a variety of drought-susceptible crops, revenue maximizing plans call for more home-grown food crops, and less cash earning and market activity. Increased self-sufficiency compelled by risk-spreading has a depressing effect upon net revenues. The introduction of sunflower and ropemaking as cash-earning possibilities is of dubious economic value to the farms under investigation. Man-hour returns from ropemaking are so unremunerative that this activity enters the plans only when labor can no longer be applied to other enterprises. Sunflower shows some promise as a cash crop if tobacco is limited by risk-spreading, but generates less revenue per resource unit than tobacco.

Imputed resource values ("shadow prices") show both temporal and spatial variation, and bear a direct relationship to net-revenue potentials under all model plans. The values of land and labor resources are similarly dependent on one another as each requires the other for expression in farm production.

Labor is a limiting resource on all farms at some time in the year. One reason for this is the outside demand for sisal sharecroppers. While there is some monthly pulse in labor shadow prices, this is greatly dampened by the sharecropping opportunity. Labor is less limiting on poorer quality lands because of the lower labor requirements per areal unit brought about by lower volume of production.

Land is also limiting in some seasons, and its imputed value is a function of both land quality and labor availability. Differences in land quality between farms have a great effect on their gross revenue earning potentials, while labor availability and productivity are also significant as determinants.

A means of increasing net revenue of equal importance with farm activity organization is the application of least-cost diets. The cost of these diets, despite the added expense incurred by palatability concessions, allows considerable savings to the peasant household in cash expenditures and/or farm resource allocations. All nutrient requirements originally set out in the models are met--often in generous excess--in the least - cost diets. Scarcest nutrients, and therefore those with the greatest imputed values, are calcium and niacin.

Conclusions

Planning Considerations

In addition to the specific revenue maximizing recommendations prescribed for the individual modal farms, certain general planning and policy recommendations which have considerable bearing on the revenue-generating potential of local farms suggest themselves.

Crop diversification. Unless a more rewarding cash crop can be found, tobacco growing should not be discouraged. Tobacco has proven itself over many years as an economically and agriculturally successful income source for peasant farms, despite world market price fluctuations. As a non-perishable farm product, tobacco is admirably suited to the isolated situation of the community, as well as possessing the ability to be withheld from the market in times of poor prices. Crop diversification efforts should be directed at finding cash crops which will fit into tobacco's off-season, so that a steadier income flow is maintained through the year. Sunflower is one such possibility.

Sisal growing. While sisal growing currently performs a valuable function as a ready source of income and an absorber of excess labor, its longe-range effects on local agriculture must be considered. The practice of planting the conuco to sisal at the end of a cropping cycle has serious implications, as sisal lands are essentially eliminated as future conuco sites. The shrinking of the area available for field rotation will inevitably cause a drop in yields as the fallow period shortens.

Outside employment. Few, if any, farms of the modal man-land ratio class considered in the study can provide full year-round employment to its household members, although all hands are required at peak seasons. Sisal sharecropping provides one solution to the problem of seasonal labor surplus. The establishment of a rural industry of some type could provide another. Ideally, the industry would be of a seasonal nature, employing workers in agriculturally idle periods. Wages should be greater than farm labor shadow prices in the months of desired operation. For example, to compete successfully for labor with sisal sharecropping, wages should be greater than RD$0.09 per hour. Ropemaking, because of its low returns to labor, is thus not promising as a new industry. As wages rise above monthly labor shadow prices, the proposed industry could afford to be less tied to the agricultural calendar. In setting wages, caution should be observed so as not to introduce wage diseconomies to the community, which would be detrimental to local agriculture.

Risk. It has been shown in this study that the risk-reducing method practiced by farmers has a prejudicial effect on net revenues. While it cannot be denied that risk-spreading is a logical practice with the agriculturally desireable effect of crop diversification, it may be that the cost of this form of risk avoidance is excessive. Government intervention in the form of crop insurance or some other means of absorbing risk might well cost only a small fraction of the losses to the gross national product caused by risk-spreading.

All-weather farm-to-market roads. Dependable year-round access to markets would create a new array of cash-earning possibilities for the farmers of Entrada de Mao. The opportunity to sell perishable food crops might provide valuable supplementary incomes, or cause the displacement altogether of tobacco as the principal crop. Moreover, it is likely that food prices would fall in the community's markets. In addition to agricultural and dietary effects, land values might be expected to be significantly altered as rent becomes a factor of economic importance.

Nutrition. It is in this area that the potential for raising net farm revenues is perhaps highest. Nutritional instruction should be an essential part of agricultural education in development efforts. Great financial savings as well as dietary improvement will result from applying least-cost diet plans. Public health efforts to eliminate intestinal parasites and disease stress can also have important economic and nutritional effects in removing curbs on full net revenue earning potential. Because of the difficulty on the part of the local farms in supplying adequate amounts of certain nutrients (i.e., calcium and niacin) and the correspondingly excessive marginal costs of such nutrients, a government program of food fortification or low cost dietary supplements should be considered as an extremely inexpensive means of promoting development.

Retrospect

LP models such as those presented in this study are only one means of planning agricultural development. Of proven value to Western and Socialist agriculture, their potential as development tools for peasant agriculture has scarcely begun to be explored. They are fundamentally different from other methods, in that information, rather than a tangible good, is the item being offered the farmer. The two items should not be regarded as alternatives in the struggle for agricultural advancement, but rather as allies, each made more effective by the presence of the other.

It is not argued that computer runs be made for every farm in a target area. A judicious selection of farms for data processing can provide information which can be interpolated for a region as a whole. Adjustments for differences in individual farms can be treated by the technique of programmed budgeting, as suggested by Timm (1972, p. 70).

There are, admittedly, four major short-comings in the models developed for the study, and further research is indicated in order to remedy them. First, provision should be made for the effects on crop yields caused by plant interactions under intercropping. While the models assume equal row yields under monoculture and intercropping, this is not necessarily true. Secondly, investigation should be made of the effects of different crop mixes on soil fertility, moisture and pests. The models of this investigation ignore the possible detrimental ecological effects which might be caused by the application of the cropping plans. Thirdly, careful record keeping on crop yields and prices should be initiated so that more representative temporal information might be available for policy making. Input-output coefficients used in the present study are for one year only, and the models are weakened thereby. The technique developed in this study for reconstructing past histories of crop failure is no substitute for reliable historical data gathered over a long period of time. Fourthly, only short-term farmer goals are treated in the models. Long-term practices, such as methods of field or crop rotation, are part of the general problem of revenue maximization, and might properly be considered. Furthermore, the welfare of the individual farmer and that of the region or nation may not always coincide. This is an important consideration, and one that merits careful analysis at some time in the future.

In conclusion, it is hoped that, with this example in mind and similar studies made elsewhere, geographers will apply their special skills, methodologies, and insights in the investigation of the spatial patterns of agricultural resource distribution and man's varied associations with the land to produce information of practical value in the continuing battle against world poverty and hunger. In the bitter days which appear to lie ahead, mankind can not only survive, but retain his humanity as well, by working in harmony with his environment. There is an urgent need for scientific planning toward this goal.

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APPENDIX I

FARM-LEVEL FIELD QUESTIONNAIRE

Name of farmer:
Location of conuco:
Date of interview:
Interview began: ended:

I Household Census

1. Tell me the names, ages and relationship of each person living in this house between September, 1970 and August 1971. If any person left the household during this period, date of occurrance.

II Land

1. How many tareas do you have?
2. How many tareas do you rent?
3. How many tareas were in crops last year?
4. How many tareas were in pasture last year?
5. How many tareas were in brush last year?
6. How many tareas of conuco were haida? hoya? llanos?
7. If you rent land, how do you pay the owner?
8. How much do you pay the owner?
9. Do you rent to anyone? How many tareas?
10. How are you paid?
11. How much are you paid?

III Conuco Production

1. For each crop grown in the conuco last year (between September, 1970 and August, 1971): amount produced, estimated production per tarea, tareas planted, money invested, quantity sold, sale proceeds, quantity retained for seed, quantity retained for animal feed, quantity given as payment for rent, quantity retained for household members, quantity retained for other uses.

2. Have you even grown any other kinds of crops?
   Which ones?
3. Why do you not grow them now?
4. Have you thought about planting any other crops?
   Which ones?
5. Why do you not grow them now?
6. Is there a tax on any of the crops which you grow?
   Which crops? How much do you pay?

IV Yard Production

1. For all fruits and vegetables grown in the yard last year: amount produced, money invested, month of harvest, quantity sold, sale proceeds, quantity retained for seed, quantity retained for animal feed, quantity retained for household members, quantity retained for other uses.

V Animal Census

1. For all livestock and poultry raised last year: total number, animals killed, animals dead from sickness or accident, money invested, type of feed, amount of feed given, number of animals sold, sale proceeds, number given to the land owner, number retained for members of the household, numbers retained for other uses.
2. Did you care for the animals of others on your land last year? What types? How many? Under what arrangements?

VI Production of Milk, Eggs, and Honey

1. How many milk cows/milk goats/ laying hens/bee hives did you have last year?
2. How much cows milk/goats milk/eggs/honey was produced?
3. How much cows milk/etc. was sold?
4. For how much?
5. How much cows milk/etc. was given to the land-owner?
6. How much cows milk/etc. was kept for the household?
7. How much cows milk/etc. was used for other purposes?

VII Fruit Production

1. For each type of fruit produced on this conuco last year: number of fruit trees, number which bore last year, amount produced, month of harvest, money invested, quantity sold, sale proceeds, quantity given to the land-owner, quantity retained for members of the household, quantity retained for other uses.

VIII Hunting, Fishing and Gathering

1. For all the animals you hunted and ate last year: type and amount.
2. For all the fish you caught and ate last year: type and amount.
3. For all the wild foods you gathered and ate last year: type and amount.

IX Food Gifts

1. For all foods received as gifts last year: type and amounts.

X Labor

1. Who worked on this conuco last year?
2. (If any person is named who is not listed in I.1) Is there any conuco worker who does not live in the house?
3. For each outside worker: name, job, how paid, how much is he paid, works on a regular basis, hours per week, works only at certain times, when, how many hours last year?
4. Did any household members work off the farm last year?
5. For each household member working off the farm: name, place of work, job, how paid, how much is he paid, works on a regular basis, hours per week, works only at certain times, when, how many hours last year.
6. Which household members went to school last year?
7. How many hours a week?
8. When are school vacations?
9. Which household members are charged with fetching water to the house and watering livestock?
10. Where do they go to fetch water? How much time does it take?
11. How many times a day do they fetch water?
12. In the last growing season, for each crop: How many man-hours to plant? to cultivate? to harvest?
13. Last year, how many man-hours did it take to clear and prepare the conuco? When was this done?
14. How many hours a week is spent in taking care of animals? working in the yard? hunting and fishing? Who performs these tasks?

XII Agricultural Techniques

1. Sketch the layout of the conuco, showing the arrangement of crops and distances between crops and rows of crops.
2. Why do you choose this conuco layout?
3. Which crops are grown apart from the rest?
4. What is the reason for this?
5. What techniques do you use for the impovement of the land?
6. What are the major agricultural problems on this conuco?

XIII Other Sources of Income

1. Apart from agriculture, do you have any other sources of income?
2. What are they?
3. How much income did they provide last year?

XIV Food Purchases

1. For each food (including oil and beverages) purchased last year: quantity bought and cost(s).

XV Diet and Health

1. How many times a day do you all eat?
2. What are the foods and drink you take at each meal?
3. What is the frequency of meat consumption? What kind?
4. What is the frequency of milk consumption?
5. What is the frequency of egg consumption?
6. What is the frequency of fruit consumption? What kinds?
7. How do you store your food?
8. How much food did you lose last year from insects, animals, and spoilage?
9. Are there any foods which you dislike? Which ones?
10. What foods do you believe would compose an ideal diet? (for each meal)
11. Are you all in good health? What are your health problems?
12. For each member of the household: outward appearance in regard to health, any frank manifestation of malnutrition symptoms, parasites or gastro-intestinal disease, height and weight.

XVI Goals

1. What do you wish from life?
2. If there were profitable outside work opportunities, would you sell your land and become a laborer?
3. Why do you not plant more cash crops and fewer food crops?
4. How do you visualize the future?

APPENDIX II

TIMING OF SELECTED CONUCO CROPS

	Month	
Crop	Planting	Harvesting
Corn: First-Rains	Sept.-Nov.[a]	Nov.-Jan.[b]
Corn: Second-Rains	March	May
Eggplant	October	January
Okra	October	January
Onions: First-Rains	August	December
Onions: Second-Rains	April	August
Peppers	October	December
Red Beans: First-Rains	Oct.-Dec.[a]	Dec.-Feb.[b]
Sesame	October	December
Sweet Potato	Sept.-Jan.[a, c]	Dec.-July[b, c]
Tobacco: Transplanted	Oct.-Jan.[a, d]	Jan.-June[b, c]
Tobacco: Non-Transplanted	Jan.-Feb.[a, c]	Jan.-June[b, c]
Tomato	October	December
Yuca	Sept.-Jan.[a, c]	May-Aug.[b, c]

[a] Planting may occur in any of these months

[b] Start of harvest period varies according to time of planting

[c] Task is performed at regular intervals throughout some or all of these months

[d] Seed-bed planting is done in October or November; transplanting of seedlings to the conuco is done in December or January

APPENDIX III

YIELDS OF SELECTED CONUCO CROPS BY FARM

	Hundredweight per Tarea				
	Farm I	II	III	IV	V
Corn: First-Rains	1.20	-	-	.97	.60
Corn: Second-Rains	-	-	1.58	1.80	1.78
Eggplant	-	-	-	2.22	-
Okra	-	-	-	-	1.87
Onions: First-Rains	-	-	-	10.40	-
Onions: Second-Rains	-	-	7.73	-	-
Peppers	-	-	-	-	1.07
Red Beans: First-Rains	.98	-	.96	.97	.71
Sesame	-	-	-	.32	-
Sweet Potato	3.84	4.59	1.89[a]	6.66	1.70
Tobacco: Transplanted	-	2.97	-	3.49	1.45
Tobacco: Non-Transplanted	2.62	-	5.53	-	-
Tomato	-	-	-	-	2.32
Yuca	4.59	4.59	6.55	6.02	5.34

[a] Approximately one-half of the sweet potato crop was destroyed by weevils

Note: Areal yields of hypothetical pure stands were derived from extrapolation of row yields.

APPENDIX IV

AVERAGE LABOR REQUIREMENTS FOR SELECTED CROPS

Crop	Man-Hours per Hundredweight	
	Planting	Harvesting
Corn: First-Rains	9.17	10.67
Corn: Second Rains	10.00	10.00
Eggplant	1.67	.83
Okra	.50	12.75
Onions: First-Rains	3.75	5.50
Onions: Second-Rains	3.75	5.50
Peppers	1.85	12.50
Red Beans: First-Rains	5.00	33.00
Sesame	1.67	40.00
Sweet Potato	1.20	8.86
Tobacco: Transplanted	7.96[a]	40.00[b]
Tobacco: Non-Transplanted	6.02	40.00[b]
Tomato	.83	2.50
Yuca	.82	3.85
Sisal	-	54.00[c]

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[a] Includes 1.96 man-hours/cwt. for planting of seed-bed, and 6.00 man-hours/cwt. for transplanting of seedlings to conuco.

[b] Includes picking and tieing of leaves

[c] Includes cutting of leaves, decortication, and hanging of fiber

APPENDIX V

SEASONAL RETAIL FOOD PRICES IN ENTRADA DE MAO

	Pesos per Hundredweight		
	Trimester I[a]	II[b]	III[c]
Rice	13.00	13.50	14.00
Spaghetti	20.00	20.00	20.00
Bread	32.00	32.00	32.00
Sweet Potatoes	7.50	6.00	6.00
Plantain	5.66	4.66	6.66
Irish Potatoes	12.25	10.50	12.00
Yuca	4.00	4.50	5.00
Cassava Bread	20.00	25.00	30.00
Peppers	10.50	10.50	10.50
Garlic	60.00	60.00	70.00
Onions	8.00	13.00	18.00
Okra	-	-	10.29
Tomato Juice	33.33	33.33	33.33
Beets	10.00	15.00	15.00
Chives	12.00	20.00	20.00
Red Beans	12.00	18.00	24.00
Broad Beans	-	-	13.33
Pigeon Peas	-	-	13.33
Sesame	20.00	20.00	20.00
Mangoes	-	2.80	-
Avocados	-	-	6.00
Sweet Oranges	1.19	-	1.00
Salt Codfish	48.00	48.00	54.00
Salt Herring	48.00	48.00	54.00
Sardines	42.85	45.53	53.57
Eggs	26.92	36.53	38.46
Milk	4.67	5.55	5.84
Meat (Chicken, Pig, Cow, Goat)	45.00	50.00	50.00
Lard	39.50	39.50	39.50
Vegetable Oil	57.82	57.82	57.82
Sugar	8.00	8.00	8.00
Tomato Sauce	50.00	50.00	50.00
Coffee	40.00	47.00	54.00

[a]January-April, [b]May-August, [c]September-December

NOTE: Prices prevailing in 1971-1972

BIOGRAPHICAL SKETCH

Marshall W. Green was born December 31, 1942 in Boulder, Colorado. He graduated from the University of California at Berkeley, receiving his B.A. in June, 1964.

In August, 1964, he joined the Peace Corps and served in a Public Health project in northeast Brazil for over two years. As a Peace Corps Volunteer, he worked as a poultry expert and advisor, as a hospital laboratory technician, and as a high school teacher of English.

In February, 1967, he entered graduate school at the University of Maryland at College Park. He worked as a Teaching and Research Assistant in the Department of Geography, September, 1968-June, 1969, as well as a programmer for the Map Project for the Blind, June, 1969-August, 1969. He was admitted to candicacy in the M.A. program in May, 1969.

In September, 1969, he entered the Doctoral program in the Department of Geography at the University of Florida. From September, 1969-June, 1972 he held a NDEA Title VI Fellowship with the Center for Latin American Studies. From September, 1972-December, 1972 he was a Research Assistant with the Center for Latin American Studies.

Marshall W. Green is a member of the Association of American Geographers, the American Association for the Advancement of Science, and Phi Kappa Phi.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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Associate Professor of Latin American
Studies in Geography

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

David L. Niddrie

David L. Niddrie
Professor of Geography

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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Professor of Soils, Geography,
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I certify that I have read this study, and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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This dissertation was submitted to the Graduate Faculty of the Department of Geography in the College of Arts and Sciences and to the Graduate Council, and was accepted as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

December, 1974

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